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Engineer Dept

H CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, pt. 2, vol. II.

ANNUAL REPORT

OF THE

CHIEF OF ENGINEERS,

UNITED STATES ARMY,

TO THE

SECRETARY OF WAR,

FOR

THE YEAR 1884.

IN FOUR PARTS.

PART IV.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

CONTENTS.

[Alphabetical Index will be found at the end of each Part.]

PART I.

SEA-COAST AND LAKE FRONTIER DEFENSES.

48TH CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, pt. 2, vol. II.

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CONTENTS.

[Alphabetical Index will be found at the end of each Part.]

PART I.

SEA-COAST AND LAKE FRONTIER DEFENSES.

THE BOARD OF ENGINEERS.

BOARD OF ENGINEERS FOR THE PACIFIC COAST.

RIVER AND HARBOR IMPROVEMENTS.

ATLANTIC COAST.

GULF OF MEXICO.

WESTERN RIVERS.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

LAKE HARBORS AND RIVERS.

PACIFIC COAST.

EXAMINATIONS, SURVEYS, AND CONTINGENCIES OF RIVERS AND HARBORS.

WASHINGTON AQUEDUCT, ETC.

PUBLIC BUILDINGS, GROUNDS, ETC., DISTRICT OF COLUMBIA.

GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN.

RECONNAISSANCES AND EXPLORATIONS.

OFFICE OF THE CHIEF OF ENGINEERS.

APPENDIX No. 1.

REPORT OF CAPT. W. H. BIXBY, CORPS OF ENGINEERS.

APPENDIXES Nos. 1 AND 2.

REPORT OF LIEUT. COL. H. L. ABBOT, CORPS OF ENGINEERS, BVT BRIG. GEN., U. S. A.

RIVERS AND HARBORS, ETC.

APPENDIX A.

REPORT OF COL. CHARLES E. BLUNT, CORPS OF ENGINEERS

APPENDIX B.

REPORT OF MAJ. CHARLES W. RAYMOND, CORPS OF ENGINEERS.

APPENDIX C.

REPORT OF LIEUT. COL. GEORGE H. ELLIOT, CORPS OF ENGINEERS.

APPENDIX D.

REPORT OF LIEUT. COL. WALTER McFARLAND, CORPS OF ENGINEERS.

APPENDIX E.

REPORT OF BRIG. GEN. JOHN NEWTON, CHIEF OF ENGINEERS, BVT. MAJ. GEN., U. S. A.

APPENDIX F.

REPORT OF CAPT. JAMES MERCUR, CORPS OF ENGINEERS.

APPENDIX G.

REPORT OF MAJ. GEORGE L. GILLESPIE, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A.

APPENDIX H.

REPORT OF MAJ. W. H. HEUER, CORPS OF ENGINEERS.

PART II.

APPENDIX I.

REPORT OF LIEUT. COL. WILLIAM P. CRAIGHILL, CORPS OF ENGINEERS.

APPENDIX J.

REPORT OF MAJ. PETER C. HAINS, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A.

APPENDIX K.

REPORT OF MR. S. T. ABERT, UNITED STATES CIVIL ENGINEER.

APPENDIX L.

REPORT OF CAPT. F. A. HINMAN, CORPS OF ENGINEERS.

APPENDIX M.

REPORT OF COL. Q. A. GILLMORE, CORPS OF ENGINEERS, BVT. MAJ. GEN., U. S. A.

APPENDIX N.

REPORT OF MAJ. A. N. DAMRELL, CORPS OF ENGINEERS.

APPENDIX O.

REPORT OF CAPT. THOMAS TURTLE, CORPS OF ENGINEERS.

APPENDIX P.

REPORT OF CAPT. THOMAS TURTLE, CORPS OF ENGINEERS.

APPENDIX Q.

REPORT OF MAJ. AMOS STICKNEY, CORPS OF ENGINEERS.

APPENDIX R.

T OF MAJ. S. M. MANSFIELD, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A.

APPENDIX S.

EPORT OF MAJ. A. M. MILLER, CORPS OF ENGINEERS.

APPENDIX T.

PORT OF MAJ. MILTON B. ADAMS, CORPS OF ENGINEERS.

APPENDIX U.

REPORT OF MAJ. O. H. ERNST, CORPS OF ENGINEERS.

PART III.

APPENDIX V.

REPORT OF MAJ. CHARLES R. SUTER, CORPS OF ENGINEERS.

APPENDIX W.

REPORT OF CAPT. JAMES B. QUINN, CORPS OF ENGINEERS.

APPENDIX X.

REPORT OF MAJ. ALEXANDER MACKENZIE, CORPS OF ENGINEE

APPENDIX Y.

REPORT OF MAJ. CHARLES J. ALLEN, CORPS OF ENGINEERS.

APPENDIX Z.

REPORT OF MAJ. WILLIAM R. KING, CORPS OF ENGINEERS.

APPENDIX A A.

REPORT OF LIEUT. COL. WILLIAM E. MERRILL, CORPS OF ENGINEERS, BVT. COL., U. S. A.

APPENDIX B B.

REPORT OF CAPT. JAMES C. POST, CORPS OF ENGINEERS.

APPENDIX C C.

REPORT OF MAJ. JARED A. SMITH, CORPS OF ENGINEERS.

APPENDIX D D.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

APPENDIX E E.

REPORT OF MAJ. CHARLES J. ALLEN, CORPS OF ENGINEERS.

APPENDIX F F.

REPORT OF LIEUT. COL. J. W. BARLOW, CORPS OF ENGINEERS.

APPENDIX G G.

REPORT OF CAPT. W. L. MARSHALL, CORPS OF ENGINEERS.

APPENDIX H H.

REPORT OF MAJ. W. H. H. BENYAURD, CORPS OF ENGINEERS.

APPENDIX I I.

REPORT OF MAJ. JARED A. SMITH, CORPS OF ENGINEERS.

APPENDIX J J.

REPORT OF CAPT. D. W. LOCKWOOD, CORPS OF ENGINEERS.

APPENDIX K K.

REPORT OF LIEUT. COL. O. M. POE, CORPS OF ENGINEERS, BVT. BRIG. GEN., U. S. A.

APPENDIX L L.

REPORT OF MAJ. L. COOPER OVERMAN, CORPS OF ENGINEERS.

APPENDIX M M.

REPORT OF CAPT. EDWARD MAGUIRE, CORPS OF ENGINEERS.

APPENDIX N N.

REPORT OF LIEUT. COL. HENRY M. ROBERT, CORPS OF ENGINEERS.

APPENDIX O O.

REPORT OF LIEUT. COL. GEORGE H. MENDELL, CORPS OF ENGINEERS, BVT. COL., U. S. A.

APPENDIX P P.

REPORT OF COL. C. SEAFORTH STEWART, CORPS OF ENGINEERS.

APPENDIX Q Q.

REPORT OF CAPT. CHARLES F. POWELL, CORPS OF ENGINEERS.

APPENDIX R R.

REPORT OF MAJ. G. J. LYDECKER, CORPS OF ENGINEERS.

APPENDIX S S.

REPORT OF COL. A. F. ROCKWELL, UNITED STATES ARMY.

APPENDIX U U.

REPORT OF LIEUT. COL. O. M. POE, CORPS OF ENGINEERS, BVT. BRIG. GEN., U. S. A.

EXPLORATIONS AND SURVEYS.

APPENDIX V V.

REPORT OF CAPT. GEORGE M. WHEELER, CORPS OF ENGINEERS.

APPENDIX W W.

REPORT OF MAJ. THOMAS H. HANDBURY, CORPS OF ENGINEERS.

APPENDIX X X.

REPORT OF LIEUT. DAN C. KINGMAN, CORPS OF ENGINEERS.

APPENDIX Y Y.

REPORT OF LIEUT. O. M. CARTER, CORPS OF ENGINEERS.

APPENDIX Z Z.

REPORT OF CAPT. H. S. TABER, CORPS OF ENGINEERS.

APPENDIX A A A.

REPORT OF MAJ. W. R. LIVERMORE, CORPS OF ENGINEERS.

APPENDIX B B B.

REPORT OF MAJ. WILLIAM A. JONES, CORPS OF ENGINEERS.

APPENDIX C C C.

REPORT OF LIEUT. THEODORE A. BINGHAM, CORPS OF ENGINEERS.

APPENDIX D D D.

REPORT OF LIEUT. GEORGE W. GOETHALS, CORPS OF ENGINEERS.

PART IV.

APPENDIX T T.

REPORT OF THE MISSISSIPPI RIVER COMMISSION.

C. B. COMSTOCK, Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A., *President*.
Q. A. GILLMORE, Colonel of Engineers, Bvt. Maj. Gen., U. S. A.,
CHARLES R. SUTER, Major of Engineers, U. S. A.,
Mr. HENRY MITCHELL, Coast and Geodetic Survey,
Mr. B. M. HARROD, Civil Engineer,
Mr. S. W. FERGUSON, Civil Engineer,
Mr. ROBERT S. TAYLOR,
Commissioners.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX T T.

MISSISSIPPI RIVER COMMISSION.

To the Senate and House of Representatives:

I transmit herewith to the House of Representatives a communication from the Secretary of War submitting the annual report of the Mississippi River Commission.

I take this occasion to invite the early attention of Congress to the continuation of the work on the Mississippi River, which is being carried on under the plans of the Commission. My sense of the importance of the improvement of this river, not only to the people of the Northwest, but especially to the inhabitants of the Lower Mississippi Valley, has already been expressed in a special communication to the last Congress. The harvests of grain and cotton produced in the region bordering upon the Mississippi are so vast as to be of national importance, and the project now being executed for their cheap transportation should be sufficiently provided for.

The Commission report that the results due to the still uncompleted works have been remarkable, and give the highest encouragement for expecting the ultimate success of the improvement.

The act of August 2, 1882, appropriated $4,123,000 for the work on that part of the river below Cairo. The estimates of the Commission already transmitted to Congress call for $3,000,000 for the continuation of the work below Cairo; and it appears from their report that all of the last appropriation available for active operations has been exhausted, and that there is urgently needed an immediate appropriation of $1,000,000 to continue the work without loss of time, in view of the approach of the flood season with its attendant dangers. I therefore recommend to Congress the early passage of a separate bill on this subject.

CHESTER A. ARTHUR.

EXECUTIVE MANSION, *January* 8, 1884.

Shfs

LETTER OF THE SECRETARY OF WAR.

WAR DEPARTMENT,
Washington City, January 7, 188

SIR: I have the honor to submit herewith, for transmission to C
gress, the annual report of the Mississippi River Commission for
year 1883.

Very respectfully, your obedient servant,

ROBERT T. LINCOLN,
Secretary of Wa

The PRESIDENT.

REPORT.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, December 21, 1882[3

SIR: The Mississippi River Commission have the honor to sub
the following report, embracing the subjects and subdivisions speci
below, to wit:

1. Progress of surveys and examinations since December 1, 1882
2. Construction.
3. Remarks on the subjects of levees and outlets.
4. Legislation.
5. Financial statements and estimates of funds for the fiscal year e
ing June 30, 1885, for "Surveys and expenses of the Commission"
for "Improving the Mississippi River."

PROGRESS OF SURVEYS AND EXAMINATIONS.

The surveys and examinations, undertaken in pursuance of the
quirements of the third section of the organic act, have been contin
From December 1, 1882, to December 1, 1883, the following prog
is reported:

Gauges.—Daily readings have been continued at the stations m
tained by the Commission, and two new gauges, at Gray's Point, M
and Columbus, Ky., have been established. This service has b
greatly improved during the past year, and its value, both as an aid
navigation and as a source of hydraulic data, greatly enhanced.
small steamer has been purchased and equipped for the duty of m
taining these gauges in correct position, and insuring accuracy of rec
and display. This boat is constantly passing up and down the ri
in the performance of this as her principal duty. She visits each ga
at least once a month. The daily readings are conspicuously displa
on bulletin boards, and are now a prominent feature of the records k
by pilots for their mutual information. The bulletins are frequen
read at night by means of the electric light.

[illegible].—No field work has been done during the year.
adjustment and reduction of previous work has been completed.

[illegible].—The line has been continued northward along the ri
from Clinton, Iowa, to Savannah, Ill. (22 miles), and thence to Lake Mi
igan at Chicago (148 miles). The reduction of the part from Clinton
Savannah and also of the remainder of the line from Grafton to K
kuk has been completed.

The record of the tide gauge on the Gulf of Mexico has been cont
ued. Owing to the considerable discrepancies in the means of differ
lunations, it has been thought unadvisable to terminate the series,

that the mean Gulf level, upon which all elevations are finally to depend, remains undetermined.

Final topography and hydrography, on the same scale as mentioned in last report, has been completed from 10 miles above Vicksburg to Donaldsonville, a distance of 297 miles; from Island No. 1 to Donaldson's Point, 60 miles; from Caruthersville to Plum Point, 58 miles; from Randolph Point to Memphis, 15 miles; and from Commerce Cut-off to Trotter's Landing, 33 miles, making a grand total of 463 miles of river surveyed during the year.

In connection with this branch of work, occasion was taken to repeat, in the fall of 1882, the cross-sections near the principal crevasses of the preceding flood, for comparison with measurements of the same sections made previous to the flood.

Detail charts (scale of $\frac{1}{10000}$) from Arkansas City to Greenville, and from Lake Providence to Waterproof, comprising 160 miles of river, have been plotted and drawn in the office. In addition, the remaining sheets to Donaldsonville are partially completed. The preparation of the preliminary chart (one inch to a mile) has been continued, five sheets, extending to Rodney, Miss., having been drawn, and five sheets, extending to the foot of Island 97, published.

Trans-alluvial levels.—The system of lines undertaken, as noted in the Report of the Commission for 1881, p. 3, to obtain information as to the heights of the alluvial bottom lands and their reservoir capacity, was completed during the past year.

Other work in the same direction, consisting of 160 miles of levels in the country between Lower Red River and the Atchafalaya, has been completed.

Observations.—The series of measurements at Paducah, Columbus, Helena, Hays' Landing, and Red River Landing, which closed in December, 1882, have been reduced. The measurements of escape through crevasses and otherwise were repeated for the flood of 1883, which was, at Cairo, the highest on record. This work was not continued below Vicksburg, since at that point the flood was several feet below that of 1882, and was no longer of unusual magnitude.

High-water marks and slope.—The collection of reliable high-water marks of 1883, and previous years, has been continued. The profile of the water surface was determined for the low water of October, 1883, from Saint Louis to New Orleans.

A financial statement and an itemized statement of the expenditure of the appropriation in act of August 2, 1882, appear below.

The following papers relating to the work of surveys and examinations are submitted as appendices to this report:

Appendix A.—Annual report of the secretary of the Commission upon the field work of surveys and examinations.

Appendix B.—Report upon, and final results of, secondary triangulation from Cairo to Keokuk.

Appendix C.—Report upon, and results of, precise leveling from Carrollton to Biloxi, and from Cairo to Fulton.

Appendix D.—Reports upon field work of topography and hydrography.

Appendix E.—Report upon the work of trans-alluvial leveling, with profiles of the lines.

Appendix F.—Reports upon and results, of observations of river discharge at various points.

Appendix G.—Report upon changes of the Mississippi River, as shown by comparison of the earliest and latest authentic surveys.

CONSTRUCTION.

At the date of the last annual report of the Commission, Dec 1, 1882, work had been fairly inaugurated on the Plum Point anc Providence Reaches, and also in the vicinity of Memphis and Vick and throughout December and January the work was pushed with vigor. Unfortunately the extremely cold weather interfered ser with the stone supply from the Ohio and Upper Mississippi, the ru ice at times entirely cutting off access to the quarries. As a conseq of this there was a large accumulation of mattress work, both fo revetment and for pile-dike foot mats, which was afloat in place, b sunk for lack of stone. In this condition of affairs, early in Fet the river began to rise rapidly, bringing down great quantities o while the heavy running ice on the Mississippi and Ohio still prev the procuring of an adequate supply of stone. Efforts were m use sacks of sand instead, but without much success, and at both Point and Lake Providence a considerable amount of mattress was lost. At the former place the uncompleted pile dikes also su considerable damage from the accumulation of drift and the stron rent, due to the rapid rising of the river. This rise continue finally culminated in a flood nearly as great as that of 1882, and tl forth a very high stage of water prevailed continuously until abo end of July. During this period work was continued, though very great disadvantages, and was of necessity mainly confined to on the dikes, which required constant watching and repairs durin long-continued high water.

After the subsidence of the flood the construction of mattress bank revetment was resumed, but the season proved unusually s and labor was scarce and inefficient. Nothing of consequence w complished until the advent of the cool weather in the fall, since time work has progressed favorably and rapidly. Every endeavo been made to place the work in as safe a condition as possible, is greatly to be feared that this can only be partially accomplish the funds now available, the balance of last year's appropriation only admit of carrying on active operations till about the mid December, after which time all work must cease until Congress n a further appropriation for its prosecution. The Commission feel they cannot too strongly urge upon Congress the necessities of th and the need of early relief, as the flood season with all its atte danger is close at hand, and the Commission before that time will exhausted all its available funds, only reserving such amounts a absolutely needed for the care and preservation of the extensiv costly plant belonging to the works. An appropriation of $1,00 made immediately could be advantageously used.

The past year, with its many vicissitudes, has been fruitful in able experience, experience which was much needed, in view of the nitude and of the untried difficulties of the work.

This experience has shown that the principles upon which the mission have based their work are perfectly sound, and in this re no modification seems necessary, though with regard to details of struction some changes have been called for.

The contraction works, consisting essentially of dikes of piling, taining curtains or screens of brush, proved generally too weak fo work imposed upon them. The great depth of water in which must be maintained, the enormous accumulations of floating drift, the long duration of the high-water period, are the main points in w

our experience differs from any previously noted with similar structures at other localities. This has necessitated much more substantial work than was at first deemed necessary, with a proportionate increase of cost. It should, however, be noted with regard to these works, upon which the main damage experienced has been concentrated, that they are not necessarily permanent in their nature, and are only intended to effect certain definite results, viz, the silting up of certain portions of the river-bed. When this object has been accomplished their work is, as a rule, ended, and their maintenance will no longer be required. Meanwhile, from their position and the style of their construction, more or less damage at each recurring flood is inevitable and must be expected; but such damage should be made good as soon as possible, and the general continuity of the dikes preserved, in order to obtain promptly the desired results.

The revetment work undertaken, wherever completed, has proved entirely successful, and but slight modification in the general style and in details of construction has been found necessary. As the officers and men gain skill and confidence in this work, better results, both as regards rapidity of execution and economy in cost, may be expected.

Next to the scarcity of labor, the greatest difficulty met with has been the insuring of an ample and timely supply of the materials used in construction, especially brush and stone. Already the local supply of brush on the works is about exhausted, and it has to be sought either up or down the river at points 60 or 70 miles distant from the works. The bulk of the stone needed has to be brought from above Cairo, as the few local sources of supply are entirely inadequate to the demands of the work. This has created a demand for transportation which has taxed the resources of the Commission to the very utmost, and a considerable increase in the number of barges and tow-boats at their disposal must be made as soon as funds for the purpose are available. In other respects the plant on hand seems adequate for the work and generally efficient; though it is proper to state here that the plant provided for commencing work on the New Madrid Reach, and part of that procured for the Memphis Reach, has been absorbed by the works at Plum Point and Lake Providence.

With regard to the results due to the still far from completed works it would seem premature to speak; nevertheless these results have been so remarkable that they cannot be overlooked. During the months of September and October the river below Cairo was extremely low and navigation was carried on with great difficulty. Between Cairo and the Plum Point Reach there was but 5½ feet and 6 feet of water at several points; between that reach and Memphis and as far down as Commerce Cut-off, 40 miles below Memphis, 6 feet was found. From this point to the head of the Lake Providence Reach there was but 7 feet available, and between the Lake Providence Reach and Vicksburg but 9 feet. Below Vicksburg there were not less than 10½ feet.

During all previous low-water seasons, when similar depths have been reported, Plum Point and Lake Providence Reaches have been fully as shoal as any points on the river, and as a rule shoaler than anything in their immediate vicinity; yet during the present season there was not less than 12 feet depth through these two reaches, and at Lake Providence, during the lowest water, over 15 feet was reported. Thus these two long stretches of habitually difficult navigation showed this year a depth twice as great as the bars above and below them, and this result can only be attributed to the works executed by the Commission. That such truly remarkable effects should have been produced by the

works in their unfinished condition is extremely encouraging as the ultimate success of the improvement.

As stated in their last report, the Commission have caused to be made of the New Madrid, Memphis, Helena, and Choctaw I with a view to preparing detailed plans for their improvemen funds for the purpose become available. Allotments were m New Madrid and Memphis Reaches, and a considerable amount procured for beginning work thereon, but owing to the non-pa the river and harbor bill it was decided to be inexpedient to un this work for the present, and such portion of the New Madrid al as had not been expended for plant was reallotted to Plum Po Lake Providence. On the Memphis Reach work outside of the proper was confined to the revetment of Hopefield Bend, a fe above Memphis.

The surveys ordered at the mouth of Red River, and for a Bayou Plaquemine, have not yet been completed, owing to the ex unhealthy character of the season, which has rendered it almost sible to keep a survey party in the field. For the same reason vey ordered at Natchez Harbor has not yet been undertaken. A phis Harbor the work in progress at date of last report under a allotment by the Commission has been completed, and the same of the revetment at Delta Point, Louisiana, opposite Vicksburg

The allotment for dredging in Vicksburg Harbor was parti pended in that manner, though the work is now suspended for set forth further on. At the mouth of Red River the same me maintaining navigation were resorted to as in several previous They were attended by failure, as in 1881, and for similar reaso

At New Orleans the construction of a mattress revetment in ton Bend has been begun and is now in progress.

On all the portions of the river under improvement repeated s have been made to note any changes which might occur, and esp those due to the works constructed. At New Orleans, in addi series of discharge measurements, covering nearly a full year, hav made.

The details of administration, and the division of the river in working districts, have remained throughout the year as described last annual report.

Full details as to expenditures will be found in the financial ments appended to this report.

WORKS BELOW CAIRO.

FIRST DISTRICT.

(Cairo to foot of Island No. 40, 220 miles in length. Officer in charge, Capt. Knight, Corps of Engineers, U. S. A.)

HEADQUARTERS, CAIRO, ILL.

In this district are included the New Madrid and Plum Point Re The former extends from the head of Island No. 8, 42 miles below to the foot of Island No. 14, a distance of 60 miles; and the latte the head of Island No. 26, 147 miles below Cairo, to the head of No. 35, a distance of 40 miles.

NEW MADRID REACH.

A low-water survey of this reach was ordered in August, 188 was carried out during the fall and early winter. The maps of th

vey have been completed, but no project for work has as yet been prepared. With the expectation of beginning work on this reach the Commission authorized the procuring of the following plant, viz: 20 pile-drivers, 40 barges, 1 machine shop, 6 quarter-boats, 4 200-feet mattress boats, 6 100-feet mattress boats, 6 screen boats, and 40 skiffs. Of this list, the pile-drivers, barges, and machine shop have been built and assigned to other works.

On December 19, 1882, it was decided to suspend such portion of the allotment as was not needed to pay for plant which could be utilized elsewhere, and on March 16, 1883, $300,000 of the allotment was transferred to Plum Point, and the balance, $187,500, to Lake Providence.

This action of the Commission was rendered necessary by the failure of the river and harbor bill, as it was deemed far more important to push the works already begun at Plum Point and Lake Providence as far along as possible than to attempt, with inadequate means, to initiate the improvement of another reach. Nevertheless, in the interest of navigation, this improvement should be undertaken at as early a date as practicable, as the bars on the reach were, during the recent low water, the shoalest and most troublesome on the river.

PLUM POINT REACH.

The work so far decided on for this reach comprises a system of longitudinal and cross dikes designed to close the chutes behind Elmot Bar and Island No. 30, a similar system for closing the chutes behind Osceola and Bullerton Tow-heads, and a third system designed to contract the water-way between Bullerton Tow-head and Yankee Bar, together with bank revetment on the left bank from Ashport to Gold Dust, on the right bank from Fletcher's to Elmot's, and from Petty's to Craighead Point, and along the outside of Osceola and Bullerton Tow-heads. Of this work at the date of the last report there had been constructed 2,700 feet of revetment near Ashport, and the head of Bullerton Tow-head had also been protected. The longitudinal dike of the Elmot or Gold Dust system had been built in part, as also a dike across the middle chute through Osceola Bar. The dike across the head of Osceola Chute was completed, and the one connecting Osceola and Bullerton Tow-heads was partly built. Subsequently five cross-dikes were commenced in Elmot Chute, and partly completed. Mattresses were constructed along the outside of Bullerton and Osceola Tow-heads, and wide foot-mats along the outside of the various dikes. Nearly all this mettress work was afloat when the river began rising in February, 1883, owing to the failure in the stone supply before alluded to. Attempts were made to sink the mattresses with bags of sand, but without success. The river rose very rapidly, and brought down immense quantities of drift, which accumulated under and against the floating mattresses, and finally tore them from their fastenings. In this manner a large amount of the mettress work which had been constructed was lost, and all attempts to renew it during the high water proved ineffectual. In similar manner the drift accumulated against the pile dikes. The foot-mats were either carried away or doubled up and destroyed, and the pressure of the masses of drift, aided no doubt by scour around the piles, overturned a large portion of the dikes which had been constructed. These breaks in the dikes relieved considerably the pressure against the remaining portions, and the greatest damage was confined to the first few weeks of the flood. Subsequently these dikes were in great part reconstructed in a much more substantial manner. Four cross-dikes

were ordered in Osceola Chute, of which three have been constru and two in Bullerton Chute, the first of which only has been ir constructed, as the chute has been the channel during the low-season. It is hoped that all these cross-dikes can be finished befo close of active operations.

The third system of dikes below Plum Point has been begur cross-dikes Nos. 1 and 2, with part of the main dike, have been b

In all, there is now standing on this reach 37,815 feet of pile di

The revetment of the outside of Bullerton Tow-head has been pleted during the present season, as also that of the head of] Osceola Tow-head. The revetment of the outside of this tow-head not be renewed for want of funds. The revetment of Ashport h been extended for the same reason. It has remained intact durir year. In spite of the damage which they sustained, the dikes did service, and a general and extensive fill was noticed behind them. they been held intact their effect would undoubtedly have been greater.

The crossing from Plum Point to Bullerton was moved down s a considerable distance, but the failure of the Bullerton Dikes er the river at low water to cut through into that chute and main channel there. It is, however, hoped and expected that the nex water will break down the bar outside and establish a channel left of the tow-head, where it is desired to locate it.

The effect of the partial concentration of the water on those pc of the reach under improvement was very marked during the lat water season. The depth of water was not less than 12 feet, the amount found on the unimproved portions of the river abo below.

For details of work in this district see report of Capt. J. G. D. K Corps of Engineers, Appendix J.

SECOND DISTRICT.

(Foot of Island No. 40 to mouth of White River, 180 miles in length. O charge, Maj. A. M. Miller, Corps of Engineers, U. S. A.)

HEADQUARTERS, MEMPHIS, TENN.

In this district are included the Memphis and Helena Reach first extending from the foot of Island No. 40, 220 miles from Ca Scanlan's Landing, a distance of 27 miles, and the second extendin Commerce Cut-off, 270 miles from Cairo, to Friar's Point, a dista 55 miles.

The first reach includes Memphis Harbor.

MEMPHIS HARBOR.

This work, which has been in progress several years under the neer Department, United States Army, was carried on last year the supervision of the Commission and by special allotment fro general appropriation.

The protection of the caving bank by mattress revetment fro freight elevator to Wolf River was completed in February, 188 all, since our last report, 5 mattresses covering 300 linear feet of have been constructed and sunk, and the upper bank has been and covered with stone throughout the whole distance, with the tion of two gaps, aggregating 450 feet. This revetment passed th

the great flood of 1883 without any damage and is reported in perfect order.

MEMPHIS REACH.

A low-water survey of this reach has been completed, but no project for its improvement has as yet been prepared.

It had been the intention of the Commission to begin work on this reach, and a considerable amount of plant was ordered for the purpose; but owing to the failure of the appropriation, work was confined during the year to the construction of a mattress revetment in Hopefield Bend, where the right bank was rapidly caving and threatening the harbor of Memphis. This work was begun in December, 1882, and carried on till February, 1883, when it was stopped by the rapidly rising river, 1,127 feet of mattress revetment having been to that time constructed and sunk. Work could not be resumed till August, 1883, and is still in progress. To date 14,485 feet of bank have been protected, the under-water mattress being 140 feet wide. That portion which was first put in has stood perfectly well, although the water was five feet deep on top of the bank during the flood of 1883. It will be necessary to carry this revetment down to Hopefield Point, and also to revet about ½ mile of the left bank below the mouth of Frame Chute.

HELENA REACH.

A low-water survey of this reach has been made, but no project for its improvement has as yet been prepared.

For details of work in this district see report of Maj. A. M. Miller, United States Engineers, Appendix K.

THIRD DISTRICT.

(Mouth of White River to Warrenton, Miss., 220 miles in length. Officer in charge, Capt. W. L. Marshall, Corps of Engineers, U. S. A.)

HEADQUARTERS, VICKSBURG, MISS.

In this district are included the Choctaw Reach, extending from Cork's Point, Arkansas, 422 miles below Cairo, to Arkansas City, a distance of 31 miles; the Lake Providence Reach, extending from Carolina Landing, Mississippi, 530 miles below Cairo, to the foot of Island No. 95, a distance of 35 miles; and also the improvement of Vicksburg Harbor.

CHOCTAW REACH.

A low-water survey of this reach has been made, but no project for its improvement has as yet been prepared.

LAKE PROVIDENCE REACH.

At date of last report work on this reach was going on actively, and considerable progress had been made on the pile dikes closing the chutes behind Skipwith's and Duncansby Tow-heads, Island No. 93, Bale-shed Bar, and Stack Island; and revetment was in progress along the face of Island No. 93. During the past season this work has been continued, the revetment of Louisiana Bend has been begun, as also the dikes closing Hopewell or Elton Chute.

In Louisiana Bend the work of revetting the bank has been com-

menced and to date about half a mile has been completed. Th work offering peculiar difficulties, the water being over 100 feet de low water, while at high stages work is impossible, owing to the depth of water and the extremely rapid current. This very impo work was much delayed by the difficulty in procuring labor and soon be stopped for lack of funds. The work completed will be very precarious condition during the next high water, as the c during the last two years has aggregated 1,500 feet in width. The ing of this shore line is absolutely essential on account of its infl on the direction of the river below. The caving which took plac year caused considerable damage to the Duncansby system of dik will be described farther on.

The Duncansby system of dikes is intended to exclude the rive the left-hand chute in front of Duncansby and Skipwith's Lan The first series built comprised five cross-dikes, and a longitu dike extending to the lower tow-head in front of Skipwith's Lar The longitudinal was a high dike; the cross-dikes were only carr the 17-foot stage. The channel, when the work began, led into with's Chute, passing between the two tow-heads. This channe been completely silted up, and the greater portion of the entire is dry at low water, but the caving in Louisiana Bend, above er's Point, during the last high water, threw the channel acros river, striking high up on the Mississippi shore, and the works a head of the chute were severely attacked, and suffered conside damage. As it was deemed desirable to hold this line as long a sible, in order to allow time for the chute to fill up and for the new nel to develop itself to the right of the tow-heads, three additional dikes were built in the chute, and a screened dike above the head upper tow-head. Later on the head of the tow-head was revetted the water went entirely over it and cut a channel through behin revetment. A heavy dike was also begun on range No. 36, and a upper dikes of the system are being strengthened, so as, if possib keep the river out of the left-hand chute during the coming high w

The Meyersville, or Island No. 93 system, includes a main dike three cross-dikes on Cottonwood Bar, which are not yet built, a across the head of Island No. 93, built last year to the 17-foot stage a high cross-dike, to 30-foot stage, built across the chute at Meyer Landing. These dikes have proved quite effective and the chute goes dry at low water.

Previous to the rise in February, 1883, 1¼ miles of low-water r ment had been constructed on the outside of Island No. 93, and th per bank protection had been completed for 1,700 feet at the upper of this, the last 225 feet had not been properly ballasted for la stone and was carried away. All the revetment below this point also lost for lack of protection of the upper bank. This work had t fore to be renewed this season and is now in progress.

At the foot of Island No. 93 begins the Baleshed system of dike comprises a longitudinal dike extending from the Mississippi sho Homochitto Landing to the head of Stack Island. Behind this l tudinal are twelve cross-dikes. Part of the longitudinal and four o cross-dikes were built last year, but only to the 17-foot stage. Subseq to February, 1883, and during the high water, work was carried on the cross-dikes were raised and strengthened, and eight others built. All the new dikes extend to above the 25-foot stage, the built with from 3 to 5 rows of piles and are wattled to a height of 6 above the present bar surface. Six of the cross-dikes are complete

the shore to the longitudinal, the six others have not yet been carried across the deep water. All the cross-dikes have foot mats, and the longitudinal has outside of it a 100-foot mat and a grillage mat and wattling wherever cross channels have been developed. The effect of these dikes has been very marked, a great fill having been secured behind them, with a corresponding deepening in the channel outside. In this system 28,000 feet of dike have been built during the year.

Much trouble was experienced at Stack Island where the river had established itself in the left-hand chute. This chute was over 80 feet deep at low water, and the Elton or Hopewell Chute on the other side of the river was over 30 feet deep. The new channel, as projected, crossed directly over Hopewell Bar. An open pile dike was built above the head of Stack Island to check the flow into that chute, and six short spurs from the right bank were thrown across the Elton or Hopewell Chute. When these works were completed the river broke through on the line desired, removing immense masses of sand and establishing itself in the position desired. These works must, however, doubtless be extended in order to keep it there.

The general result of the works has been a very marked increase of depth at low water. During the past season there was not less than 12 feet, and at the lowest water where the channel had cut out there was over 15 feet.

The systems of construction described last year have not been materially altered except in the direction of giving greater strength to the dikes, which, as now made, are much stronger, having from 3 to 5 rows of piles, and being all provided with foot mats. In 3-row dikes the middle row is wattled, in 5-row dykes the wattling is on the 2d and 4th rows. Wattling has replaced the curtains or inclined mats used last year, being found cheaper and more efficient.

In revetment work the hurdle mattresses described in our last report are still used, the only modification being the introduction alongside the poles of jointed iron rods of $\frac{3}{8}$ or $\frac{5}{8}$ inch iron for the purpose of increasing the longitudinal strength.

VICKSBURG HARBOR.

Prior to August, 1882, work at this locality had been for several years in progress under the Engineer Department, United States Army. Since that time it has been carried on under the supervision of the Commission, and has received an allotment from the general appropriation. Previous to this past season, work had been confined to the revetment of Delta Point, opposite Vicksburg, and the continuation of this work was in progress at the date of our last report. At that time 1,100 feet of the new work had been completed. Subsequently the work was continued with but slight modifications till February 10, when the allotment was exhausted. In all, 4,000 linear feet of substantial revetment was constructed, leaving about 500 feet to be built this winter. The cost of this revetment, which it is believed will be rarely, if ever, exceeded, was $13.37 per linear foot. It passed through the last flood without any damage, and seems to be in every respect satisfactory. The plan of improvement proposed for the harbor proper of Vicksburg contemplated the excavation of a basin in front of the town, connected by a canal with the deep water in the river. For this season it was proposed to excavate a basin 300 feet wide and 1,700 feet long in front of the elevator, and to connect it with deep water in the lake by a canal 150 feet wide, the west entrance to the lake being also kept open. All dredging was to be to the

zero of the Vicksburg gauge. The contract for this dredging was l 12.1 cents per cubic yard and, after many delays, work was finally be on April 5, and continued till September 18, when the Commission dec to stop it. During this time, 350,035 cubic yards of mud were remo The basin for a width of 160 feet was dredged to the zero of the ga and for a further width of 160 feet to the reference + 5 feet. The c was excavated for a width of 80 feet to the zero plane, and an atte was made to dredge the west entrance to the lake, which, since the ject had been approved, had filled up to the extent of 17 feet. The terial was hard sand and the dredging was so difficult that it wa dered to be abandoned on August 22. As the river fell, the side the dredged basin slid in and the bottom was pushed up by the we of the soft mud lying beyond the dredged area. This upheaval amou to about 8 feet in depth, and the basin was re-excavated for a widt 80 feet to the zero plane. Meanwhile, the continued fall of the r surface gave a considerable head to the water impounded in the l and it finally cut through the sand-bar at the west entrance, so now boats drawing 5 feet are able to enter at a 12-foot stage, whe before, at the 20-foot stage, all boats were excluded.

This effect, while very fortunate for the town, is in nowise pe nent, as this cut will certainly fill up at the next high water, and not cut out again so readily. A survey was made at low water, w showed that since May, or while the river was declining, a fill had ta place over the area covered by the proposed canal and basin amoun to from 5 to 20 feet in depth. Prior to May the fill had only been al one foot. On the line of the proposed canal alone the remova 1,255,486 cubic yards more than originally estimated has already come necessary. It is needless to say that the Commission, in appro this plan, had not anticipated such a state of affairs as this. Repe surveys, extending over the whole period since the formation of the off, had shown that the fill, gradually diminishing in its yearly in ment, had finally practically ceased as far as the inner harbor was cerned, and only on this condition could the plan have been rec mended. When confronted by such an enormous fill, taking place, m over, on the falling stage of the river, and requiring in consequenc be removed during the low-water stage, it became obviously necessar call a halt until the matter could be further investigated. Such an nual fill as this will require $200,000 for its removal, and as it mus done during the low-water period, it would require a large fleet of dre to accomplish it. Some changes have recently taken place at You Point, and above Delta, which have tended to throw the river neare Vicksburg. The eddy current up the east arm of the lake was served to be greatly increased after June 1, and undoubtedly caused great deposit. It is quite possible that this increased flow was du the changes alluded to. If this, however, be the case, these chan may progress still further, and the annual fill may become even grea in any case it would be extremely unwise to attempt any further pr cution of the plan for the present. The diversion of the Yazoo into lake has been proposed with a view to keeping it open; but this is e mated to cost $1,600,000, and the excavation of the canal $766,000. removal of the annual deposit will cost $200,000, or say $2,600,000 the whole project, with no certainty as to the results. The annual c merce of Vicksburg is 10½ millions of dollars.

The following projects have been proposed:

1st. To abandon the lake and establish the town landing at Klei ton, holding Delta Point securely by extending the revetment. T latter must be done in any case.

2d. To dredge the west entrance annually, and to keep the basin clear. This would be temporary, and would cost at least $30,000 per annum after the first year.

3d. To divert the Yazoo into the west arm of the lake, dredging out the basin and connecting canal. This would cost $1,850,000, with annual dredging to an uncertain amount.

4th. To divert the Yazoo into the east arm of the lake and along the city front, dredging out the basin and canal to the river. This would cost $2,600,000 and would require annual dredging in the canal.

The first project involves the abandonment of the old harbor of Vicksburg, and is, naturally, extremely distasteful to the citizens of that place; the last two projects are expensive and by no means certain; while the second can at best be but temporary in its effects.

In the opinion of the Commission, further study of the whole subject is required before any final recommendation can be made; nevertheless, with a view to affording relief to the harbor during such time as will necessarily be required for this study, the Commission recommends that during the coming season an attempt be made to carry out the second project above described, should the conditions be found to be favorable.

For details of work in third district see report of Capt. W. L. Marshall, United States Engineers, Appendix L.

FOURTH DISTRICT.

(Warrenton, Miss., to Head of Passes, 484 miles in length. Officer in charge, Maj. Amos Stickney, Corps of Engineers, U. S. A.)

HEADQUARTERS NEW ORLEANS, LA.

This district embraces the improvement of Natchez Harbor, the rectification of Red and Atchafalaya rivers, a lock at Bayou Plaquemine, and the improvement of New Orleans Harbor.

NATCHEZ HARBOR.

A survey with a view to improvement was ordered at this place, but owing to the sickly season it has been found impossible as yet to make it. The caving of the bank in Giles' Bend has not been very great, but that in Marengo Bend has been more severe. The work required is bank revetment, and can be estimated on this winter.

RED AND ATCHAFALAYA RIVERS.

During the past low water, it again became necessary to send dredge-boats to Old River to attempt to keep open navigation into the Red River. Although they reached the scene of operations while there was still a through channel depth of not less than 5 feet, the effort failed utterly, and, for a period of three or four weeks, navigation was entirely suspended. In fact, for a part of this time, the water-way entirely disappeared.

The experience of this year leaves no doubt of the absolute uncertainty of any such method of preserving navigation, during low water, into Red River. While in many years it may succeed, it is utterly inefficient in the face of the unfavorable conditions that may recur any season. The dredging fleet cannot operate until the water has fallen to a certain stage. After this stage is reached, it is entirely probable that the fall may continue so rapidly as to develop the bars much faster than

the dredges can remove them. The difficulty of maintaining a chan upwards of four miles long, of navigable depth and width, in a se mentary river, falling several inches a day, with a current unable scour from its own debility, and the unctuous and adhesive quality the bed material, would seem to be sufficient. But it is much increas in unfavorable years by the falling of the water more rapidly than t banks can dry out and solidify, or than the overflow ponds a short d tance back can drain. On such occasions the semi-fluid banks slou down in immense masses, at times entirely choking the water-way.

These difficulties may recur any year, and render uncertain any a tempt to keep open Red River navigation by such methods, during lo water.

Still, as no better temporary method is known, and as this meth has succeeded in a majority of the years in which it has been tried, a as the commercial benefits of maintaining water communication with large producing region during the months when it is most needed f shipments are very great, exceeding the cost of dredging operations, is recommended that, until permanent improvement of this navigation accomplished, sufficient appropriation (as provided for in the acco panying estimates) be made to renew the work of dredging at this poi when it may again become necessary.

Surveys and examinations at this locality have been prosecuted und almost equal difficulties. Immediately on the subsidence of the la flood parties were put into the field to secure information necessary f the preparation of a plan for the permanent improvement of the jun tion of these three rivers; but, owing to the natural difficulties of t ground and the unhealthfulness of this region, their labors are still i complete.

Fuller details and discussions of these topics will be found in the r port of Maj. A. Stickney, United States Engineers, district officer, su mitted as Appendix M.

The following brief description of the existing regimen, and of t conditions which must be harmonized in any permanent plan of improv ment, as observed during the past two floods, is submitted. The se tional area of Lower Old River has contracted considerably, while t enlargement of the Atchafalaya has continued. These changes a clearly the effect of the floods.

The fill in Old River is the result of the absence of current during t equilibrium held between that portion of the flood coming down t Mississippi and the overflow through the Tensas Basin, re-enforced b Red River. The scour in the Atchafalaya, considered in connectic with the fill in Old River, proves that the volume causing it is n drawn directly from the Mississippi, but rather from the overflow in t Tensas Basin. The shape of the sand reefs left by the flood curre substantiates this. A dam across Lower Old River, therefore, would n change the existing tendencies of the floods. The equilibrium of t accumulated mass of flood water in this region is first disturbed by decline in the Mississippi, which starts the current in that directio But so immense is this volume of overflow that the fall is checked by when near a bank full stage. In 1882 it lingered fifty-one days betwee the 42 and 41 foot marks on the gauge at Red River Landing. Whe once within the banks, the decline is more rapid. The fall of the Atch falaya is still slower than that of the Mississippi, as in addition to i share of the Tensas it has to collect and carry off its own overflo which spreads from the Mississippi to the Têche.

The flow through Old River towards the Atchafalaya usually sets i

after mid-stage on the decline is reached, and becomes more fixed as the water continues to fall. These observations are general, and a local rise in either the Mississippi or Red River may disturb or reverse the movement. A flow through the Old River to the Mississippi is, under present conditions, advantageous to the navigation of the former stream, as it has greater velocity and less sediment than a current in the opposite direction.

The exclusion of the overflow from the Tensas Basin, by the completion of its levee system to Blackhawk, would prevent the equilibrium between the Mississippi and overflow waters in and about Old River and the head of the Atchafalaya, which is noticed in floods, and would tend to increase, both in duration and amount, the flow from the Mississippi down the Atchafalaya by way of Lower Old River. This change would probably not only prevent the further filling of Lower Old River, but would enlarge it, and ultimately accelerate the enlargement of the Atchafalaya. The prevention of the escape of flood waters, complete or partial, down the Atchafalaya would have, as an immediate effect, the greater or less increase of flood height in Old River, and steeper slope from its mouth down the Mississippi. This would precede the ultimate adjustments of the bed to the increased volume. This subject is further discussed under the head of levees and outlets.

The Commission is as mindful of the importance of this part of their work as of its difficulties. Upon the completion of surveys and examinations now in progress, full report and recommendations will be made.

LOCK AT BAYOU PLAQUEMINE.

The surveys for this work are not yet completed, having been delayed by the unhealthiness of the past season.

NEW ORLEANS HARBOR.

The project for laying 10,000 feet of mattress revetment 400 feet wide in Carrollton Bend was approved September 18, 1882. Work was begun October 9, 1883, but has made little progress to date, owing to trouble in securing a supply of brush.

In the third district the plan of scouring out the mud from under the wharves by the use of a tug has been tried with success.

On the right bank from Westwego to Algiers there has been serious caving, involving much loss to property of considerable present and much greater prospective value. Fully 40,000 feet of bank will require protection.

An interesting series of discharge observations were obtained at Carrollton between January 27 and September 7, 1883. The discharge was measured 148 times, and the observations extended from a 2-foot to a 15½-foot stage.

For details of work in this district see report of Maj. Amos Stickney, United States Engineers, Appendix M.

PLANT AND GENERAL SERVICE.

There was in use on the work during the past season the following plant, in part owned by the Government and in part chartered:

Owned by the Government.—One hundred and eighty-nine barges, thirty-nine quarter-boats, four screen-boats, three machine-shop boats, five steam tow-boats, one pumping-boat, twenty five mattress boats, four hydraulic graders, one steam-tug, and sixty-two pile-drivers.

Chartered.—Six steamers and six barges.

The general service of supply and towage, as well as the constructi of plant, was throughout the year in charge of Capt. C. B. Sears, Co of Engineers, United States Army, the executive officer of the Comm sion in the department of construction, to whose report reference c be made for details. (See Appendix H.)

Estimates.

At a meeting held June 26, 1883, an estimate was made for the co tinuance of work then in progress, and this estimate was duly forward to Congress through the honorable the Secretary of War. At that ti the Commission did not deem it best to make any recommendation estimate in reference to new works of improvement, the works then progress being in a comparatively incomplete state, and their results yet undeveloped. Since that time the progress of the works and t favorable results produced by them have been such as to warrant t belief that work can be undertaken in one or more additional places, it shall be the will of Congress to carry it on simultaneously in mc places than those at which it is now in progress.

In this case the Commission would recommend that the improveme of New Madrid Reach be first undertaken; and secondly, that of Me phis Reach.

Estimates for this work are submitted herewith, and the estimate pr viously sent in is repeated.

LEVEES AND OUTLETS.

Work, under the allotment made by the Commission, from the appr priation of August 2, 1882, has been continued during the year on tho levees which were not finished before the flood of 1883. It is expect that all will be completed before the expiration of this year. Mo detailed notice of this work will be found in the reports of the distri officers.

The Commission now recommends the continuation of levee wo during the next season on the fronts of the Tensas and Yazoo Basins.

Surveys and examinations, to ascertain the condition, cost, and effe of levees, have been continued during the past year. The limit topography of the surveys extends back from the river, to include tl site and height of all existing levees.

Besides this, special examinations of two distinct characters hav been undertaken and carried far enough to yield important inform tion.

1st. To ascertain the effect of outlets, particularly in the form of cr vasses, resurveys have been made in the neighborhood of several of tl great breaks of 1882, to compare with the general survey which wa extended over the river in the years 1880 and 1881. The result of th work is graphically shown and accompanied by descriptive text i Appendix D.

In every observed case large loss of section occurred as follows:

Place.	Contraction.	Contractio
	Square feet.	*Percentage*
Malone's	2,200	.(
Riverton	11,000	.:
Bolivar	8,400	.1
Mound Place	23,800	.:

The above figures are the means of numerous lines run at each place. It is worthy of notice that the later of these comparative surveys were taken at lower stages of water than the earlier, and therefore, through the bars, other things being equal, a more deeply excavated bed might be expected in the later surveys. But, as the contrary is the case, it may be inferred that the observed net results are decreased rather than exaggerated by the relative conditions prevailing at the time of survey. Similar observations have been made during the year at Bonnet Carré crevasse, with this difference: the foregoing comparisons were between channels before and after the breaking of the crevasses, while the following is between a channel during the flow of a crevasse and after its closure. The results harmonize. Through this part of the river (35 miles above New Orleans) such depths prevail at all stages that great changes may occur without affecting navigation; but valuable opportunity for observation on crevasse effects was afforded, at a point where conflicting statements had been made with equal vehemence. Careful surveys were therefore made while the crevasse remained open, and repeated over the same lines, in the fall of 1883, after the crevasse was closed and the flood of that year had passed. The final results of this work are not yet prepared, but the change observed is scour throughout the reach below the crevasse, amounting to approximately 12 per cent. of the low-water area.

In the last report of the Commission (Appendix F, p. 116) will be found the results of gauging observations on the Mississippi, at and above Saint Louis, in the years 1880 and 1881. Similar observations were undertaken in the fall of 1881, at Paducah, on the Ohio, and at Columbus, Helena, Hay's Landing, and Red River Landing, on the Mississippi below Cairo, and continued into the fall of 1882. The value of this series was much enhanced by the fortunate occurrence in this year of the greatest recorded flood. Accompanying this report, as Appendix F, will be found the tabulation and plotting of their results. They have not been long enough available to have received complete investigation. Certain facts, however, are quite apparent in both series. It is observable that the rate of velocity and discharge, during a rise, increases more rapidly while the river is still within its banks than during the higher stages when the banks are submerged, or escape occurs through outlets. At several of the stations the increase of velocity is entirely arrested at about a bank-full stage, and, before that elevation is reached, absolutely greater velocities, and even discharges, were found than at higher stages, when much of the volume was lost over the banks. This phenomenon probably continues while the swamps are filling, and the draft from the river is across the banks. After they are filled to or near the height of the river, this indirect motion, and its loss of power, ceases, or becomes a very gentle one, generally parallel with the river, forming what may be termed a "water bank." It is fairly inferable from this, that if the conditions under which a certain curve, representing the increment of velocity and discharge, while the river is still within its banks, was developed, were continued, the form of the curve, throughout its upward extension, would be maintained, and that the additional height required for levees to restrain maximum floods would be less than that computed alone from a consideration of the increase of volume.

An illustration of the accuracy of this inference, as well as of the way in which flood heights are immediately augmented within the river bed, under existing physical conditions by crevasse outlets, is found in the comparative conduct of the high waters of 1882 and 1883, along the front

of the Yazoo Basin. Although the volume discharged by the flood of : was unquestionably greater than that of the subsequent year, owin its duration, yet, from Cairo to Helena the waves attained hei; nearly equal to each other, and, in both cases, above those of prev records. The same conditions, as regards outlets, or the gaps in Saint Francis levees, prevailed during the two years. At Helen both floods, the maximum heights were reached on the return of overflow from the Saint Francis Basin. But the first of the two fl under consideration wrought great havoc on the levees at the hea and along the upper part of the front of the Yazoo Basin. Of 1,500 cubic feet per second gauged at Helena at the top of the flood, one-th or 500,000 cubic feet, were estimated by the assistants of the Commis charged with that duty, as escaping from the river through these bre

Notwithstanding this depletion, which left in the river bed a vol not exceeding that which the Helena and Hay's Landing gauging dicate can be discharged at these stations at a stage, respectively, 6 5 feet lower than the maximum readings of the year, or, approximat at a bank-full stage, the greatest flood heights were reached along entire front of the basin.

The most destructive work of this phenomenal flood was, howe near the lower end. The water leaving the river through the creva at the head, and along the front, sought the lower levels near the mo of the basin. The Yazoo River and other branches of the natural dr age system were inadequate to afford it exit. It accumulated in basin to a height of several feet above the level in the river, until, o topping the levees, an equalization of height was established betw the river and basin, above the mark that would have been reached the flood passing through a proper channel.

In 1883, the flood wave reached Helena with approximately the sa height as in the previous year, but overflow into the Yazoo Basin prevented by the holding of the levees which had broken the year fore. In passing along the Yazoo bottom, the wave did not vary terially, in height, from that of 1882, until the lower end was reach Here, owing to the exclusion of overflow from the head of the basin, little return flow to the river, beyond the natural drainage, occurr and the height of 1882 at Vicksburg, the nearest gauge, was not reac by about five feet.

While these two floods attained, approximately, the same heig along the part of the river under discussion, the difference in velo was very marked. Gaugings in 1882, when the overflow into the Ya Basin was enormous, established the sluggish movement of the wa during high stages. This was also the personal observation of classes engaged on the river; engineers, steamboatmen, and plant In 1883, when the flood wave was excluded from the Yazoo bottom, great velocity along its front was universally noticed by the same servers.

The conclusions to which these facts contribute evidence may be tl stated. The loss of volume through high-water outlets causes bot diminution of velocity and a deflection of the thread of movement of stream towards the outlet, accompanied by loss of the power necess to transport the material with which it is loaded. The excess of lo is dropped in the bed, decreasing the section below the outlet. Wl these conditions recur frequently, and are extended over long parts the river, as the front of any one of the great basins, where volum alternately reduced and augmented, the injury inflicted on the river a channel or as a drain is cumulative, leading to general deteriorati

If the change from low water to flood, with its enormous range in the measure and direction of the river's forces, is unfavorable to the development of a navigable and permanent channel, or an effective discharge section from the different conditions, in the same place, at different times, it certainly increases these difficulties to allow the introduction of different conditions, at the same time, in different places.

The relief from excessive flood heights which might have been anticipated from the decrease of discharge below the outlet is not realized, owing to the immediate diminution of velocity, and of *vis viva*, and the consequent contraction of sectional area. Besides, the flood-water which escapes through the outlets is returned to the river at a point lower down under conditions which give it a power of increasing the flood's height to an elevation which would not have been reached by the same volume passing down the legitimate channel.

The facts observed during the past year, of which the more important have been here recapitulated, have corroborated the views of the Commission heretofore expressed in reference to the utility of levees as a means of channel improvement. This statement is made, as heretofore, with the limitation that for purposes of channel improvement merely, the limit of economy is reached with the confinement of the ordinary flood, and does not extend to the restraint of the abnormal or extraordinary flood. The result of this qualification is that the building of levees to the height necessary to protect the alluvial basin from overflow is not necessary as part of a logical plan of river improvement. The work of determining approximately what will be the necessary height of such system of levees has been in the hands of a committee since a time prior to the last report, who will report upon it as soon as the extensive investigations necessary to reach satisfactory conclusions upon the subject can be finished.

In the mean time it is proposed to complete the closure of gaps in the existing levees along the Yazoo and Tensas fronts begun a year ago, as the most economical and the shortest method of shutting off the escape of water into those great reservoirs and securing so far the benefit of the entire volume of the river's ordinary discharge in the improvement of the channel. Beyond that the Commission is not prepared at this time to make any specific recommendation for construction of levees as a means of channel improvement, and reserves the subject for further consideration.

The act creating the Commission makes it the duty of the Commission to consider the subject of the prevention of destructive floods, and, as bearing upon that matter, there is submitted for information the following summary of the probable extent and cost of such system of levees as would be necessary for that purpose.

It may be stated, further, that there are serious practical difficulties in the way of constructing a system of levees no higher than would be necessary for the confinement of ordinary floods, and at the same time protecting them against disastrous injury from the great floods which occur at irregular intervals. The practicability and probable cost of such protection is one of the subjects in the hands of the committee before referred to. It is obvious that for the secure protection of the valley from overflow there is necessary a system of levees high and strong enough to withstand the greatest flood. No other means of protection is practicable or even possible. These facts suggest obviously the idea of co-operation between the General Government and the communities interested in the prevention of overflow in the maintenance of a levee system which shall serve at the same time the purpose of

e of cubic yards of earthwork required for levees on Mississippi River, &c.—Cont'd.

Location.	Length.	Grade.	Contents.	Remarks.
	Miles.		*Cubic yards.*	
uisiana line to pposite Warrenton.	100	....	3, 426, 080	This is the estimate of the assistant engineer in charge of the line for raising the levees 3 feet for their entire length. As the grade of the line is very uneven, this quantity of earthwork, applied to the lowest places, would raise the grade of the line more than 3 feet. It is believed to be sufficient for a safe grade. (See Appendix —.)
posite Warrenon to Red River.	150	....	5, 140, 000	No survey has been made of this line, but the same provision is made in the estimate as in that from the Louisiana line to opposite Warrenton, viz, a uniform addition of 3 feet over the entire line, on an assumed height of 6.06 feet.
d River to forts below New Orleans.	279	2 feet above high water, 1882.	6, 652, 000	This line is now complete in length, but of insufficient grade. The necessity for higher grade is explained in the following text. The assumed mean height is 7 feet, to be raised to 9 feet. In the execution of the work much the greater part of the addition would, of course, be made to the upper part of the line.
Horn Lake to Friar's Point.	70	....do	1, 276, 000	This estimate is based on surveys and computations made for the purpose (see Appendix —). An addition of half a foot is made to the original, making the grade of this estimate 2 feet above high water, 1882.
riar's Point to Sunflower.	34	....do	620, 000	There exist but two breaks in this line, but the estimate is prorated per mile from the foregoing line.
unflower to mouth of Yazoo River.	220	3 feet above high water, 1882.	3, 925, 000	This estimate is based on the report of the United States assistant engineer and engineer of Mississippi levee district (see Appendix —). The same remark applied to estimate from Louisiana line to Warrenton is true here.
aton Rouge to forts below New Orleans.	200	2 feet above high water, 1882.	4, 838, 000	The remarks applied to line from Red River to Forts is repeated here. The conditions are precisely the same.
			45, 775, 080	
ost at 25 cents per cubic yard.	....	....	$11, 443, 770	

e Commission is not prepared to state that these are the exact es that are likely to be adopted, but it is not believed that grades cess of these, on the average, will be required for the purposes orth in the organic act, unless a change of regimen occurs from remote cause, such as the extensive clearing of the precipit us of some of the tributary basins.

has been the experience of the General Government, as well as of iparian States, that such embankments as the above can be conted for an average price not exceeding 25 cents per cubic yard, g a result of $11,443,770.

conclusion of this subject, the Commission considers it necessary ll the attention of Congress to peculiar conditions existing below River. This section of the river is in a state of much greater sta- than is found in any other part of its course below the junction e Missouri. At a short distance below Red River it becomes nar- and deeper. It has been leveed throughout for a great many . No flood complications arise here, as above, from the return of low water which has escaped from the river at points higher up. all reaches the sea through the numerous delta bayous on either

side. Its bed, enlarged by levees, is fairly adapted to the d service which has hitherto been imposed upon it.

During the floods of 1874, 1882, and 1883 this part of the ri filled to its utmost capacity. The levees were a wash for hun miles, and the waves of passing steamers rolled over them. disastrous breaks occurred.

The gaugings at Carrollton in 1883 showed that the river point was only discharging, at a maximum, about 1,100,000 cu per second, while those at Red River Landing in the previo showed that double this volume, or about 2,200,000 feet, found down the valleys of the Mississippi and Red rivers.

While it is not anticipated that the completion of the levee Tensas front to within 20 miles of Red River, and the conf within the river of that part of the flood which has been allowe cape above will cause greater flood heights at the mouth of Re it seems certain that it will have the effect of increasing and constant the outlet of the Mississippi through Old River do Atchafalaya.

Measures that may become necessary to prevent this, by dimi the discharge of the Atchafalaya, or by directing more of the Re flow down the Mississippi, will throw into the latter stream a in excess of any known discharge. While this increased volume undoubtedly make room for itself by ultimate enlargement of i it could only do so by the work of scour, the resistance to which be indicated and measured by increased slope, or greater elev surface throughout that part of the river while undergoing enlar

Such additional service should not be imposed upon a region i have been adopted the measures necessary, under existing con for protection from inundation, without due preparation for the in height which will be given the floods.

LEGISLATION.

The Commission repeats with emphasis the recommendation n three preceding reports, that provision be made by law for the ap ation, by suitable proceedings, of land and material necessary work of Mississippi River improvement undertaken by the Gover Within the past year some serious inconvenience has been suffere exorbitant demands made by land-owners for brush and piles. materials are, in most cases, worth little or nothing to the owne are unsalable to any buyer except the Government at any price at the prices some owners ask for them they would make a larg of cost. It is not believed that there would be frequent occasion sort to condemnation of private property, if such proceedings we thorized, as in most cases the existence of the power would be a cient preventive of extortion; although cases may arise in whi possession and exercise of the power would be highly important.

It is highly desirable, also, that Congress shall prescribe by la extent to which material found on islands and bars in the river m used without payment of damages. It is believed that the su right of control and improvement of rivers navigable for inter-state merce which is vested in the United States carries with it the ri use in the work of improvement, without the consent of any indiv owner, all such material as may found within the limits of the ri sein, and constituting part of it. Upon this point differences of o are liable to arise between the engineers in charge and riparian p

tion, to avoid which there should be such express provision of law as will define the respective rights of the Government and the private owner as clearly as possible.

It is recommended also that provision be made by law for retaining control by the Government over areas of lands built up from deposits induced by the works of improvement placed in the river bed. These amount in some instances to hundreds of acres, and in some localities riparian owners may be disposed to claim possession of them to the detriment of the improvement. It is expected that in most such cases it will be found desirable to encourage the growth of trees upon the newly made banks, and occupy them in that way for many years, and perhaps permanently.

It is regarded as important, also, that a law shall be enacted for the punishment of any person who shall make a cut-off at any neck or bend of the Mississippi River. The history of the river indicates a tendency to recurring cycles of change. A cut-off is followed by a sudden increase of velocity in its vicinity, and by rapid caving above and below. These are likely to cause other cut-offs, one after another, and there then results a widely-extended and long-continued disturbance of the regimen of the river. During the continuance of such a period, works of improvement in the channel would be attended with the greatest difficulty. No great cut-off has occurred since that at Vicksburg in 1876, and the present conditions of the river in that respect are regarded as favorable. But the conditions are also existing for the introduction of a cycle of change by the making of a single cut-off, the injurious consequences of which it is impossible to estimate. Such events have happened in the past through the lawless acts of individuals, and against these, stringent penalties should be provided.

FINANCIAL STATEMENT.

Appropriation for surveys and expenses of the Mississippi River Commission, act of March 3, 1883.

Balance on hand December 16, 1882	$91,780 88
Appropriated by act approved March 3, 1883	150,000 00
Total	241,780 88
Expended from December 16, 1882, to November 30, 1883, including estimated liabilities	174,700 00
Balance which it is estimated will be required during remainder of fiscal year ending June 30, 1884	67,080 88
	241,780 88

The estimate of funds for fiscal year 1885, which was transmitted to the honorable the Secretary of War on June 25, 1883, is here repeated.

ESTIMATE OF FUNDS FOR SALARIES AND EXPENSES OF THE COMMISSION FOR NEXT FISCAL YEAR.

To continue the "surveys of the Mississippi River between the Head of the Passes, near its mouth, and its headwaters, now in progress"; to make "additional surveys and examinations of said river and its tributaries"; to make such additional examinations and investigations, topographical, hydrographical, and hydrometrical, as are necessary for maturing a plan for the permanent improvement of the entire river; for salaries and expenses of the Commission in traveling, mileage, and inspection, for office expenses, computing, draughting, &c., and for publication of maps and results	$200,000 00

The estimate of funds for works of improvement for the fiscal 1885, which was transmitted to the honorable the Secretary of W June 26, 1883, is here repeated.

ESTIMATE OF FUNDS FOR WORKS OF IMPROVEMENT FOR FISCAL YEAR ENDIN 30, 1885.

For works of improvement on the Mississippi River below Cairo, including works in progress in the Lake Providence, Plum Point, and Memphis Reaches; the completion of the closing of existing crevasses and outlets on the Tensas and Yazoo fronts; the rectification of the Red and Atchafalaya Rivers, and the harbors of Memphis, Vicksburg, Natchez, and New Orleans	$3,000

In addition to the above, and as explained in the foregoing r the Commission presents the following:

Supplemental estimate for the New Madrid and Memphis Reaches for fiscal year June 30, 1885.

For work on the New Madrid Reach	$1,000
For work on the Memphis Reach	675

FINANCIAL STATEMENTS.

Appropriation for improving Mississippi River, act of August 2, 1882.

Balance December 1, 1882	$2,388
Amount expended to November 1, 1883, including outstanding liabilities (estimated) to January 1, 1884, for steamboats, pile-drivers, and other floating plant; for materials, tools, supplies, and labor, continuing and beginning work at Plum Point, and Lake Providence, Memphis, and New Madrid; for subsisting and quartering the labor employed, and for payments on contracts for construction and repair of levees	2,187
Balance available and unpledged January 1, 1884, and which will be required for care of property and maintenance of organization during the remainder of the fiscal year	200
	2,388

Appropriation for New Orleans Harbor.

Balance on hand July 1, 1882	$147
Expended from July 1, 1882, to November 1, 1883	38
Balance available November 1, 1883	109
	147

Appropriation for improving mouth of Red River.

Balance on hand July 1, 1882	$90
Expended from July 1, 1882, to November 1, 1883	51
Balance available November 1, 1883	38
	90

Appropriation for Natchez Harbor.

Balance on hand July 1, 1882	$8,
Expended from July 1, 1882, to November 1, 1883	2,
Balance available November 1, 1883	5,
	8,

Résumé.

Total amounts of funds in Treasury and in hands of disbursing officers, November 1, 1883:	
Appropriation for improving Mississippi River	$844,717 13
Appropriation for New Orleans Harbor	109,378 91
Appropriation for mouth of Red River	38,841 74
Appropriation for Natchez Harbor	5,331 42
Total	998,269 20
Estimated liabilities to January 1, 1884, including retained percentages and balances due on contracts for levee work and outstanding liabilities for material and labor on works of construction	798,000 00
Balance available, as above	200,269 20

CHAS. R. SUTER,
Major of Engineers, U. S. A.
HENRY MITCHELL,
Coast and Geodetic Survey.
B. M. HARROD.
ROBERT S. TAYLOR.
S. W. FERGUSON.

I concur in the foregoing report, except so much of it as relates to levees and outlets, on which subject I will submit my views separately.

C. B. COMSTOCK,
Lieutenant-Colonel of Engineers, and Brevet Brigadier-General,
President Mississippi River Commission.

I concur in the foregoing report of the Commission, with the single qualification that the value of levees as a factor in the problem of channel improvement in preventing the wide dispersion of flood waters, is not affirmed in the report in sufficiently positive terms, and with that clearness and prominence to which, in my judgment, it is entitled.

Q. A. GILLMORE,
Colonel of Engineers, Brevet Major-General, U. S. A.

As I am unable to concur in the part of the report relating to levees, I submit the following remarks:

The Commission state—

> The act creating the Commission makes it the duty of the Commission to consider the subject of the prevention of destructive floods, and, as bearing upon that matter, there is submitted for information the following summary of the probable extent and cost of such a system.

The Commission submits an estimate for levees, to prevent destructive floods, from Commerce, Mo., to the forts below New Orleans, and proposes heights for them of two or three feet above the high water of 1882. The cost of the proposed system is estimated at $11,443,770, and, for the reasons stated hereafter, is, in my judgment, too small for any adequate system of levees intended to prevent destructive floods and (except at intervals of 15 or 20 years) to secure the property of the inhabitants behind them from danger of destruction.

Before a system of levees can be planned the question must be decided whether it shall be attempted to confine the greatest floods, or only those somewhat less than the greatest. When it is remembered that

the cost of these levees will necessarily be great; that, as they high, breaks through them will involve large costs in repairs; the object is to make possible the safe existence behind them of a la productive population in the alluvial bottoms they protect; th the expectation of such a population can justify the large expe volved; that breaks in the levees, when the bottoms are filled plantations, would involve enormous loss of property; that the height of floods in rivers is now believed to increase as the countr drain is cleared up; in view of all these considerations it seems the plan to face at once a great flood, and to provide for its confinem tween levees.

It may be said that with interest at 3 per cent. it would be c to allow great floods once in ten or fifteen years to overtop and h damage the levees than to incur a greater expense to avoid an ev occurs only at such intervals of time. But, as has already been sa only economical justification of the expense involved in an e system of levees is the belief that in time the whole region pro from overflow shall become populated and highly productive. that time approaches the damage done to levees by floods whic over them would be insignificant in proportion to the incalc greater damage done to the population behind them.

Moreover, great floods are not rare.

At Cairo, between 1862 and 1883, inclusive, four floods have r or exceeded a reading on the guage of 50.8 feet; the highest l reading being 52.4 feet, in 1883. A flood of 51.5 feet may then be l for once in ten years.

At Memphis, between 1858 and 1883, inclusive, the gauge readi equaled or exceeded 34.0 feet six times; the highest reading bei feet, in 1882. A flood of 34.5 feet may be expected once in ten

At Helena, between 1867 and 1883, inclusive, floods have fou equaled or exceeded a gauge-reading of 45.8 feet; the maximum 47.2 feet, in 1882. A flood of 46.5 feet may be expected once years.

At the mouth of White River, between 1862 and 1883, inclusi floods have five times given a gauge-reading of 46.6 feet, or mor highest being 48.5 feet, in 1882. A flood of 47.5 feet may be ex once in ten years.

At Vicksburg, between 1858 and 1883, inclusive, floods hav times given gauge-readings of 48.8 feet or more; the highest bei feet, in 1862. In 1882 the flood only reached 48.8 feet, the ma since 1867, and may have had its height diminished by the Vic cut-off of 1876. A flood of 49.0 feet may be expected once in ten

At Natchez, between 1858 and 1883, floods reached a gauge-r of 47.9 feet or more five times; the maximum being 50.3 feet, i A flood of 48.0 feet may be expected once in ten years.

At Red River Landing, between 1867 and 1883, the gauge has i years had a flood reading of 46.3 feet or more, the maximum bei feet in 1882. A flood of 47.0 feet may be expected once in ten y

At Carrollton, floods have reached a gauge reading of 15.4 f more, five times between 1859 and 1883, the highest being 15.9 1862. A flood of 15.6 feet may be expected once in ten years.

These statements refer to the river as it has been since 1858.

In the preceding statements of floods that may be expected c ten years, the heights are adopted from an examination of the h of the floods mentioned.

The following table recapitulates the preceding information, an

also the lowest readings on the gauges, with their years, and the high-water readings in 1882:

Distance in miles from Cairo.	Stations.	Highest high water.	Year.	Lowest low water.	Year.	Gauge-readings for flood to be expected once in ten years.	Gauge-readings for flood of 1882.
		Feet.		*Feet.*		*Feet.*	*Feet.*
0	Cairo	52.4	1883	−1.0	1871	51.5	51.8
230	Memphis	35.1	1882	−1.0	1872	34.5	35.3
306	Helena	47.2	1882	0.0	1872	46.5	47.2
380	White River	48.5	1882	0.0	1872	47.5	48.5
507	Vicksburg	51.1	1862	−1.3	1872	49.0	48.8
700	Natchez	50.3	1862	0.0	1872	48.0	47.9
784	Red River Landing	48.6	1882	0.0	1872	47.0	48.6
855	Carrollton	15.9	1862	−1.6	1872	15.6	15.0

If the figures in the last two columns of this table be compared, it will be seen that in five cases the flood of 1882 was higher than the flood that may be expected once in ten years, and in three cases lower, and that in the average of all it was 0.4 foot higher. Considering the smallness of this excess above the floods to be expected once in ten years, the fact that at four places out of eight the flood of 1882 was not the maximum flood observed in the last 20 or 25 years, and the probability that the height of floods will increase in the future, it seems proper that in the plan for any general system of levees, if the principle of keeping out all floods, whatever their height, should be surrendered (a step of doubtful advisability), the plan should at least provide for holding a flood like that of 1882.

In what follows, that flood will be the one considered.

Adopting the flood of 1882 as the one to be confined, the next question is what height of levees is necessary.

From the investigations of the Commission, the flow of the flood of 1882 at its maximum down the Mississippi Valley, whether in the river proper or in the bottom lands, is now at least approximately known. With a complete system of levees on the river banks, the whole of that flow would be confined between them.

The following table gives the approximate results of the observations of the Commission (many of them not yet published) which were made on the floods of 1882 and 1883:

Stations.	Maximum discharge observed in flood of 1882 in river proper.	Amount which was flowing down valley outside of river.	Total flow past.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*
Columbus	1,600,000	200,000	1,800,000
Fulton (estimated from observations of 1880)	1,200,000	600,000	1,800,000
Helena	1,540,000	360,000	1,900,000
Lay's Landing	1,060,000	940,000	2,000,000
Red River Landing	1,600,000	600,000	2,200,000

Observations determining the relations between gauge-readings and corresponding discharges were made at several stations. If those gauge-readings be platted as ordinates and the corresponding discharges as abscissas, the resulting broken line which deviates somewhat from a

ight line is called a discharge curve. This discharge curve for t
ising river is usually tolerably regular until the river gets above i
anks, when it may become irregular and complicated from the esca
f water over the banks and from variations in the slope of the ma
iver, due to floods in tributaries or to return of water from the swam
nto which it had previously escaped.

But if the river were leveed throughout its length, it seems probab
o far as the investigations of the Commission yet go, that at places u
ffected by tributary flow the discharge curve for the confined river
ll stages would be a continuation of that of the unconfined river
tages less than, or equal to, that at which escape over banks begins

If this should be verified by a complete study of the subject, not
made by the Commission, the method of determining the gauge readi
at a place where discharge observations have been made which wo
ass a given discharge with the river thoroughly leveed, would be
rolong graphically the observed discharge curve, continuing it w
he form it had before overflow began up till it corresponds to the
ired discharge. The gauge reading corresponding to that discha
would be the corresponding height of the confined water surface.

These discharge curves at Columbus, Helena, Hay's Landing, and I
River Landing are given in the Commission's report for 1883. Any
an examine the result of prolonging them and form an idea of
ew gauge heights, although different persons would differ somew
n estimating their prolongations. From the discharge measureme
and the observations of flood escape over river banks in the flood
1882 and 1883, by Mr. Johnson and Mr. Stewart, it is known that in
lood of 1882 the maximum flow across the latitude of Columbus, I
was approximately 1,800,000 cubic feet per second, which at Red R
Landing increased to about 2,200,000 cubic feet.

With a thorough system of levees these quantities would have l
confined between the levees, and the question now is, how much w
the levees have raised the river surface above the height it actually
in 1882?

At Columbus, Ky., overflow begins at about 95 feet on the gaug
prolongation of the discharge curve in the way previously stated give
a discharge of 1,800,000 cubic feet a stage about 3 feet above the f
of 1882.

A discharge curve for Fulton, Tenn., is given in the Commissio
port for 1881. A prolongation of that curve gives for 1,800,000
charge a gauge reading of about 72 feet, or 10 feet above the flo
1882.

The maximum discharge across the latitude of Helena, Ark., fo
flood of 1882 may be taken as 1,900,000 cubic feet. Prolonging
Helena discharge-curve to this amount, the gauge reading is abo
feet above high water of 1882.

At Hay's Landing, just below Lake Providence, the maximum
charge across its latitude in the flood of 1882 may be taken as 2,00
cubic feet. The discharge curve prolonged to this amount gives a g
reading 10 feet above the flood of 1882.

At Red River Landing the question of flood height with high le
will depend on the amount of water that is allowed to escape dow
Atchafalaya. The maximum observed discharge at Red River Lan
in 1882 was 1,600,000 cubic feet. The estimated flow across the lat
of Red River Landing was 2,200,000, so that if 200,000 or 300,000
feet were allowed to go down the Atchafalaya, the flow below Red
Landing would be 1,900,000 or 2,000,000 cubic feet, so that the ra

of all the levees below Red River Landing would be necessary to hold this increase of 300,000 or 400,000 cubic feet per second.

Where there was a flow of from 500,000 to 900,000 cubic feet per second down the valley, outside of the river, in the flood of 1882, as was the case for long distances above and below Fulton and Lake Providence, there will be for long distances levees needed whose heights above the flood of 1882 will approach the heights of those needed at Lake Providence (or Hay's Landing) and Fulton.

A good system of levees should rise 3 feet above the expected heights of the confined water. No provision has been made for this in these remarks, because at several points the flood of 1882 was the highest of which we have accurate records, and in this paper it has not been proposed to confine the highest floods, although that is essential in a thorough and effective levee system.

Nor has the possible lowering of the river slope, which might occur some time after the building of the levees, been taken into account. The first effect of building levees would be to raise the flood surface. I know of no facts of experience which give data for determining either the amount of such ultimate lowering or the time required for it.

As stated by the Commission, a thorough study of the subject of levees has not yet been made; until then, accurate estimates are impossible, and the heights above the flood of 1882, of 3 feet at Columbus, 10 feet at Fulton, 4 feet at Helena, and 10 feet at Lake Providence, given above, are only approximations. Such as they are, they make it impossible for me to concur in the estimate of $11,443,770 as the cost of a general system of levees from Commerce, Mo., to the Forts, adequate to preserve that country from destructive floods.

C. B. COMSTOCK,

Lieutenant-Colonel of Engineers, and Brevet Brigadier-General,
President Mississippi River Commission.

NEW YORK, *December* 22, 1883.

The Hon. ROBT. T. LINCOLN,
Secretary of War.

(Through the Chief of Engineers.)

[illegible] Mississippi River Commission.

[Appropriation of August 2, 1882.]

Items.	Services assistant engineers.	Services [illegible] &c.	Tools.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Mileage.*	Miscellaneous.	Totals.
[illegible]											$8,333 33
[illegible]		$3,[illegible]	$2 17	$163 01	$1,840 80	$447 31		$14 50	$4,784 49	$79 37	10,661 93
[illegible]	$[illegible]	3,4[illegible]	25 13	16 97			$6 00	834 05		83 75	5,903 90
[illegible]	[illegible]	[illegible] 75						40 55			452 80
[illegible]	[illegible]	1,7[illegible]	6 00	132 40	421 47	612 80		1,293 25			4,233 98
[illegible]	4,410 00	8,017 10	60 52	646 10		1,007 84	966 50	991 25		172 00	17,240 43
[illegible]											277 50
[illegible]											229 00
[illegible] of Atchafalaya	751 00	900 92	34 25	47 25		25 00		152 45		*1,394 00	3,401 77
[illegible]	1,305 03	3,800 58	471 85	131 47	39 37	79 20	88 50	306 70		69 81	6,485 41
[illegible] connection	570 50	814 83		5 05			2 25	144 25		14 32	1,588 10
[illegible]	1,210 00	2,831 41	100 00	0 15			47 10	203 86		45 20	4,455 02
Reduction of field work	18,140 88	118 03	110 41	391 41			66 84	17 75			18,851 32
Reduction of maps											61 55
[illegible] of maps											3,[illegible]10 75
Hydrography and topography	19,050 05	27,000 73	9,135 36	2,072 12	9,004 01	706 53	1,416 96	5,572 36		500 80	76,[illegible]
High and low water marks	995 27	808 00	603 86	73 15	178 25	27 40	62 31	287 05		7 00	3,012 95
Levee map	433 33										488 89
Totals	49,025 50	54,847 95	10,692 95	4,288 04	11,582 90	3,030 13	2,650 40	9,808 02	4,784 49	2,491 70	

Item.	Services assistant engineers.	Services clerks, &c.	Rent.	Fuel.	Prof. works and charts.	Furniture.	Drawing materials and supplies.	Transportation.	Stationery.	Miscellaneous.	
Office	$180 00	$6,[illegible]	$1,800 00	$847 07	$[illegible]	$74 48	$[illegible] 41	$[illegible] 48	$[illegible] 18	$[illegible] 18	[illegible]
[illegible]											[illegible]

* Line of levels run by contract at $10 per mile.

SUMMARY.

Balance from appropriation March 3, 1881	$38,005 72
Appropriated by act August 2, 1882	150,000 00
Cash deposited, sale of fuel to officers, and overpayment vouchers	188 50
Total	188,194 22
Expenditures for fiscal year ending June 30, 1883	178,352 69
Balance	9,841 53

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary and Disbursing Officer Mississippi River Commission.

TABLE OF TOTAL EXPENDITURES, CONSTRUCTION DEPARTMENT, MISSISSI[illegible] COMMISSION, FROM THE BEGINNING OF CONSTRUCTION UP TO NOVEMBER [illegible]

[Covering appropriations of March 3, 1881, and August 2, 1882.]

New Madrid Reach	[illegible]
Plum Point Reach	1,4
Memphis Reach and Harbor	[illegible]
Lake Providence Reach	1,
Vicksburg Harbor	[illegible]
Delta Point, La	[illegible]
Survey of Helena Reach	[illegible]
Survey of Saint Francis front, first district	[illegible]
Survey of Saint Francis front, second district	[illegible]
Survey of unleveed fronts, third district	[illegible]
Survey of unleveed fronts, fourth district	[illegible]
Survey of Cubitt's Gap	[illegible]
Choctaw Bend survey	[illegible]
Observations at Carrollton, La	[illegible]
Closing Bonnet Carré Crevasse	[illegible]
LEVEES.	
Second District.	
Yazoo front	7
Third District.	
Tensas front	2
Yazoo front	3
Fourth District.	
Atchafalaya front	10
Tensas front	2
Total	4,2

TABLE OF TOTAL EXPENDITURES FROM SPECIAL APPROPRIATIONS.

Natchez and Vidalia (June 30, 1882, to November 30, 1883)	[illegible]
Mouth of Red River (to November 1, 1883)	5
New Orleans Harbor (July 1, 1882, to November 1, 1883)	3
Total	9
Total from all appropriations	4,3

Respectfully submitted.

CLINTON B. SEARS,
Captain Engineers, U. S. A.
Secretary Construction Committee, Mississippi River Comm

LIST OF APPENDICES ACCOMPANYING THE FOREGOING REPORT.

LIST OF PLATES ACCOMPANYING THE FOREGOING REPORT.

Description.	Designation. Appendix.	Designation. Plates.
Sketch of triangulation	B	I, II
Level discrepancies	C	I
Progress sketch, topography	D	I
Sketch of sections sounded before and after the principal crevasses of the flood of 1882	D	II
Profiles of above	D	III, IV, V, VI, VII
Transalluvial levels Profile of line No. 1 Profile of line No. 2 Profile of line No. 4 Profile of line No. 5 Profile of line No. 6 Profile of line No. 7 Profile of line No. 8 Profile of line No. 9	E	I, II, III, IV, V, VI, VII, VIII
Discharge observations at Paducah, Ky	F	I
Discharge observations at Columbus, Ky	F	II
Discharge observations at Helena, Ark	F	III
Discharge observations at Hays' Landing, Miss	F	IV
Discharge observations at Red River Landing, La	F	V
Sketches of changes in river, 1810–1883 Grand Gulf to Natchez Natchez to Red River Red River to Morganza Morganza to Baton Rouge Baton Rouge to Claiborne Island	G	I, II, III, IV, V
Comparison of sections of 1851 and 1883	G	VI, VII, VIII, IX
Profiles high-water widths, 1851 and 1853	G	X
Survey of Plum Point Reach made in October, 1883	J	*I
Progress sketch; Osceola, Bullerton, and Plum Point Dikes	J	II
Progress sketch; Gold Dust Dikes	J	III
Progress sketch; Osceola Upper and Middle Dikes	J	IV
Progress sketch; works at Bullerton Tow-head	J	V
Sections of dikes	J	VI
Sections of mattress and method of sinking	J	VII
Oscillations of the Mississippi River at Plum Point	J	VIII
Comparison of cross-sections, Plum Point Reach	J	IX
Hopefield Bend and Memphis Harbor	K	I
Sketch of Bordeaux Chute	K	II
Construction works, Lake Providence Reach	L	I, II
Comparative sections of construction works	L	III
Dikes, Lake Providence Reach	L	IV, V
Chart of Lake Providence Reach	L	VI, VII
Sketch of mattress head	L	VIII
Details of mattress head	L	IX
Sketch of revetment	L	X
Vicksburg Harbor in October, 1883	L	XI
Vicksburg Harbor, sections of canal	L	XII, XIII
New Orleans Harbor, November, 1883	M	I
Diagram of discharge measurements	M	II
Comparison of profiles in Nine-Mile Bend	M	III
Total sheets	....	....

*In 2 sheets.

APPENDICES.

APPENDIX A.

ANNUAL REPORT OF THE SECRETARY OF THE COMMISSION UPON THE FIELD WORK OF SURVEYS AND EXAMINATIONS.

OFFICE OF MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
Saint Louis, November 13, 1883.

GENERAL: I have the honor to submit the following report of surveys and examinations during the fiscal year ending June 30, 1883:

Outfit.—During the year the fleet was increased to accommodate three topographical parties by the addition of two new boats, named the Illinois and Kentucky, counterparts, respectively, of the Mississippi and Louisiana.

The old boats have been thoroughly repaired, and the Pioneer enlarged. One of the iron launches was lost in a storm at Helena, about the end of October. After several days' search by a snag-boat, it was conceded to be impossible to recover it, and the attempt was abandoned.

The tug Mignon and survey boat Missouri were inspected by Captain Marshall on February 10, and his recommendations that the Missouri and the hull of the Mignon be abandoned, the machinery of the latter being taken out, having been approved by the Chief of Engineers, have been carried into effect.

Instruments.—The old instruments were thoroughly repaired, as noted in last report. The following have been purchased during the year: 4 transits, 3 Wye levels, 4 sextants, 3 prismatic compasses, 2 pedometers, 2 hand levels.

There have been transferred to this appropriation from that for the survey of Northern and Northwestern Lakes: 1 chronometer, 1 iron standard bar, 1 standard meter.

Organization and methods.—The only change to be noted is in the programme for precise leveling, in which the instructions have been so modified as to require that each observer shall duplicate his own work in opposite direction, so as to form a loop beginning and ending on the same bench. In this connection attention is invited to a report by Assistant L. L. Wheeler on cumulative errors, submitted herewith.

Progress and cost.—Precise levels were carried from Carrollton to the tide gauge at Biloxi, 87 miles; from Keokuk to Fulton, 171 miles; and from Fulton to Savannah, 21 miles. The last section is a part of the continuation of the line to Chicago, which has since been completed.

The cost of the work in the other sections was as follows:

Carrollton to Biloxi:	
Total field cost	$2,778 36
Cost per mile of duplicated work	31 93
Keokuk to Fulton:	
Total field cost	3,252 05
Cost per mile of duplicated work	19 08
Cost per mile of river	19 02
Average cost per mile of duplicated work for the two sections	23 46

The work on the Carrollton–Biloxi section was undertaken during the windy season on the Gulf coast, and, to meet this contingency, observing tents were provided. This was their first use in our work, and they were found of such great advantage that they have been employed on subsequent work, and have enabled much windy weather to be utilized.

This section was along a line of railroad, and a hand-car was kindly loaned by the company for transportation. It was found to so materially contribute to the progress of the party, that on subsequent work, lying along a railway line, a hand-car was purchased and added to the outfit of the party.

The tabulated results of the final computation for the above lines, and also for the line from Grafton to Keokuk, noted in the last annual report, are herewith submit-

ted, with field reports by Assistants J. B. Johnson and J. A. Paige, and rep[...] tention by Assistant L. L. Wheeler.

Topography and hydrography was carried from Arkansas City to Greenville, [...] and from Lake Providence to Donaldsonville, 3[..] miles; a total of 3[..] miles [...] parties were engaged on this work, and their performance may be summari[zed as follows]:

First party, Assistant J. A. Ockerson, Arkansas City to Greenville, and [...] Bayou Sara:

Number of miles of river ....

Number of square miles of topography ....

Number of square miles of hydrography ....

Total area surveyed in square miles ....

Total field cost ....

Cost per mile of river ....

Cost per square mile of survey ....

Second party, Assistant L. L. Wheeler, Warrenton to Natchez:

Number of miles of river ....

Number of square miles of topography ....

Number of square miles of hydrography ....

Total area surveyed in square miles ....

Total field cost .... $22[...]

Cost per mile of river ....

Cost per square mile of survey ....

In connection with the work of this party the sections of the previous surve[y from] Malone's to Arcadia, from Riverton to head of Ozark Island, from Bolivar to C[...] Comb, and from Mound Place to Arkansas City, were resounded.

The sections sounded are at and below the principal crevasses of the flood of [...] This work comprised 21 square miles of hydrography, costing \$57.65 per squa[re mile].

Third party, Assistant C. M. Winchell, Lake Providence to Warrenton, and Bayou Sara to Donaldsonville:

Number of miles of river ....

Number of square miles of topography ....

Number of square miles of hydrography ....

Total area surveyed, square miles ....

Total field cost $23,

Cost per mile of river ....

Cost per square mile of survey ....

For the three parties:

Total area surveyed, square miles ....

Cost per square mile ....

Field reports on the above work by assistants Ockerson, Winchell, Wheel[er ...] Wood, H. B., are submitted herewith.

Transalluvial levels were completed on the following lines:

No. 5. Up Cypress Creek.

No. 6. Grand Lake to Bayou Macon Hills.

No. 7. Lake Providence to Yazoo City.

No. 8. Saint Joseph, west to high land.

No. 9. Fort Adams to Avoyelles Prairie, and thence across Bayou Bœuf a[nd ...] River.

The total distance of 164 miles was accomplished in a season of 174 days.

The total field cost was \$5,318.90, giving a cost per mile of \$32.43.

A report, by Assistant E. S. Davis, of the entire work is submitted herewith.

Observations to determine the escape of water from the river were made from [...] to Vicksburg at the top of the flood of 1883. Below Vicksburg the flood was [not of] sufficient magnitude to warrant the continuance of the observations.

Determination of high-water marks have been continued, and the low-wat[er pro]file was extended from Commerce to Natchez.

The observation parties mentioned in last report as having begun work at Pa[ducah,] Columbus, Helena, Hays' Landing, and Red River Landing, continued the me[asure]ment of sections and discharges during a year, at the expiration of which the[y were] disbanded. The results have been partially reduced, checked, and tabulated [in this] office, and are herewith submitted, together with reports of the chiefs of the [parties] at Paducah, Columbus, Hays' Landing, and Red River Landing.

To ascertain the effect of the closure of Bonnet Carré crevasse, a hydrograph[ic sur]vey of 6 miles in front of it was made in November, 1882. This survey is now, N[ovem]ber, 1883, being repeated.

A resurvey of the Atchafalaya was made in December, 1882, and January, 1883, to determine by comparison with a previous survey, the amount of enlargement of that stream.

I am glad of another opportunity of bringing to the attention of the committee the zealous and efficient services rendered by the assistant engineers and other employés of the Commission.

The permanent force was somewhat increased during the year by the retention of the principal officers of the third topographical party. The grade of work has been higher than we have heretofore attained. This has been accompanied by a marked reduction of cost, due to the increase of rate. These gratifying results are largely due to the policy heretofore pursued, of so arranging the work in field and office as to admit of its being done by a comparatively small force, kept continuously employed.

The slight disadvantages which this system presents are repaid a hundred fold by the personal interest in, and enthusiasm for, the work shown by a very large majority of those engaged upon it; without which the results sets forth in this report would have been impossible.

A feature of the office work of the past year has been the successful substitution of printing from types for hand-lettering on our detail sheets. The cost is very much reduced, and the appearance of the charts improved. In this connection the services of Mr. J. A. Ockerson are deserving of especial mention.

For details of expenditures, the committee is respectfully referred to the itemized statement of expenditures submitted to the Commission.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary.

To General C. B. COMSTOCK,
President Mississippi River Commission, and
Chairman Committee on Surveys and Examinations.

APPENDIX B.

FINAL REPORT UPON A SECONDARY TRIANGULATION OF THE MISSISSIPPI RIVER BETWEEN CAIRO, ILL., AND KEOKUK, IOWA., EXECUTED UNDER THE ORDERS OF THE MISSISSIPPI RIVER COMMISSION, 1880-'81.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., December 1, 1883.

GENERAL: I have the honor to submit herewith a memorandum compiled from the records of this office, relative to the secondary triangulation from Cairo to Keokuk, accompanied by the results in tabular form, and a sketch of the system, the whole intended to form a final report upon this portion of the work.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary.

General C. B. COMSTOCK,
President Mississippi River Commission and
Chairman of Committee on Surveys and Examinations.

I.—The system is composed of 146 principal stations and 4 auxiliary stations, to connect the triangulation with the Chester and Cape Lacroix bases. Most of the stations are situated on the bluffs on either side of the valley. They are connected by 97 single triangles, 20 quadrilaterals, 3 pentagons, and 1 hexagon.

II.—The work depends on the following known lines:

1. A secondary base at Cairo, measured by a party of the United States Lake Survey. The length and azimuth of this base and the geodetic co-ordinates of its extremities were furnished by the office of that survey. Its length is 1,646.78 meters. (For description of this base, see Report of Chief of Engineers for 1877, Part II, page 1196.)

2. A secondary base at Chester. The length and azimuth of this base were determined by Assistant G. Y. Wisner in 1880. Its length is 3,255.07 meters.

3. The line Dryer-Insane Asylum, at Saint Louis. This line was furnished by the office of the Coast and Geodetic Survey. It depends for length and azimuth upon the American Bottom base, opposite Saint Louis, and for geodetic co-ordinates of its extremities, on the Saint Louis astronomical post. It is in the fifth triangle from the base. Its length is 13,331.3 meters.

4. A secondary base near Grafton, measured by Assistant Wisner in 1881. The

azimuth of a line near this base was determined, but not with sufficient accurac be used, except as a check. The length of the base is 2,031.61 meters.

5. A secondary base at Louisiana. The length and azimuth of this base were termined by Assistant Wisner in 1881. The base was connected with the Louisi astronomical post. For description of this post, see Report of Chief of Engineers 1879, page 1918. The base is 2,705.10 meters in length.

6. A secondary base at Keokuk, measured by Assistant Wisner in 1881. The muth of base was determined by Assistant John Eisenmann in same year. Its len is 1,297.38 meters.

A base was also measured, with steel tape, at Cape Lacroix, but was used onl a check.

III.—The following instruments were used:

Repsold universal instrument No. 1. Diameter of horizontal limb 10 inches.* Li graduated to 4 minutes, reads by two microscopes to 2 seconds. Angles measured order around the station, positive and negative, direct and reversed. Eight sets w taken uniformly distributed over the limb, giving 16 pointings at each station.

Troughton & Simms No. 1. Diameter of horizontal limb, 10 inches. Limb gr uated to 5 minutes, reading by two microscopes to one second. Programme same for Repsold.

Troughton & Simms No. 2 (of the Mississippi River Commission). Same as Trou ton & Simms No. 1. Programme same as for Repsold.

Troughton & Simms No. 2 (of the Lake Survey). Diameter of horizontal limb, inches. Limb graduated to 5 minutes reading, by two microscopes to one seco Programme same as for Repsold.

None of the instruments closed the horizon. The limit of closure of triangles wa seconds. The instruments were mounted on tripods of rough timber, which were l standing. The observer stood on a platform disconnected from the instrument su port.

The stations were marked by stones 3 feet in length, dressed to 6 by 6 inches at e end, the balance rough. A small hole was drilled in the top. They were plant vertically, the top projecting but a few inches above ground.

The targets used in the triangulation from Cairo to Grafton were octagonal po covered with alternate zones of black and white cloth. A nail in the bottom was in the hole in the top of the marking stone, and the target was then plumbed. Wh the station was occupied the target was removed and reset before leaving.

For the greater part of the stretch from Grafton to Keokuk the target used co sisted of four parallel wires fastened at bottom to a circular block by a wire ring, a fastened above by three other horizontal wire rings, which, with the block at botto divided the target into three sections. Strips of white cloth were fastened to opp site wires of the first and third sections, one strip to each section, and at right angl to each other. A strip of black cloth was fastened at an angle with the white stri to two auxiliary wires attached to the second and third rings.

This target gave no phase, and presented an illuminated surface whether the su was before or behind it. To support the target a cross-piece was fastened to the t of the platform which supported the observer, and above the observer's head. A ho in the cross-piece was centered over the hole in the marking stone. A nail projecti from the block at bottom of target was placed in this hole, and the target was th plumbed and guyed to the corners of the platform. The target was not disturb when the station was occupied.

IV.—For the preliminary reduction single triangles were adjusted to closure (qua rilaterals and pentagons were adjusted to satisfy local conditions), side and azimut equations being neglected. The lengths and azimuths of sides were then comput for the stretches given below. The discrepancies were:

From—	To—	Number of triangles.	Discrepancies.	
			In length.	In azimuth
				Obs.—comp. ″
Cairo	Chester	39	1 : 6,000	+21.
Chester	Saint Louis	23	1 : 100,000	+ 9.
Saint Louis	Grafton	35	1 : 30,000	....
Grafton	Louisiana	22	1 : 13,000	†−10.
Louisiana	Keokuk	25	1 : 25,000	+ 4.

* Erroneously stated as 12 inches in previous reports.
† Saint Louis to Louisiana.

The final reduction was made separately for each of the five stretches into which e work was divided by the six known lines before enumerated. It consisted of a ast square adjustment, in which the observed lengths and azimuths of bases were ssumed as correct, and all angles were given equal weight.

The conditions to be satisfied by the finally adjusted angles were that all triangles hould close, and that the computed lengths and azimuths of bases should agree with heir measured lengths and azimuths. The geodetic co-ordinates were then computed, ll latitudes and longitudes being referred to the Cairo astronomical post.

The final discrepancies between the observed values of latitudes, longitudes, and zimuths and the corresponding values as computed from Cairo, are as follows:

	Latitude.	Longitude.	Azimuth.
	Obs.—comp.	Obs.—comp.	Obs.—comp.
	"	"	"
Chester	*+6.13		−0.12
Saint Louis	+4.77	−2.90	+0.17
Louisiana	+1.56	−1.09	+0.04
Keokuk			−0.02

* Latitude at Chester only approximate.

A special report on the least square adjustment of the stretch from Cairo to Grafton, prepared by Assistant G. Y. Wisner, who made the computation, may be found in the Report of the Mississippi River Commission for 1882, page 62.

Tabulated results of secondary triangulation from Cairo to Keokuk.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	Meters.	° ′ ″	° ′ ″	° ′ ″
1	South Base	108 19 51.58	50.75	1,646.78	172 32 07.19	37 01 28.97	89 11 23.19
2	North Base	38 25 19.24	19.71	2,851.28	30 57 21.69	37 02 21.94	89 11 31.84
3	Bowles	33 14 50.76	49.55	1,866.65	244 11 35.51	37 01 02.61	89 12 31.18
		01.58	00.01				
2	North Base	71 57 02.60	01.33	2,851.28	30 57 21.69		
3	Bowles	68 18 08.10	04.66	4,239.74	142 38 41.30		
4	Taylor	39 44 55.05	54.04	4,143.21	282 52 44.56	37 02 51.93	89 14 15.28
		05.75	00.03				
3	Bowles	26 03 27.60	24.93	4,239.74	142 38 41.30		
4	Taylor	69 01 27.70	25.54	1,869.71	253 36 13.06		
5	Nimbus	84 55 08.64	09.55	3,974.38	348 41 47.25	37 03 09.04	89 13 02.69
		03.94	00.02				
4	Taylor	89 57 49.24	49.62	1,869.71	253 36 13.06		
5	Nimbus	52 40 08.50	09.45	3,080.67	126 17 06.25		
6	Dickey	37 21 59.04	60.94	2,449.59	343 38 06.61	37 04 08.17	89 14 43.21
		56.78	00.01				
4	Taylor	37 20 03.76	01.30	2,449.59	163 38 23.44		
6	Dickey	63 15 12.28	11.24	1,511.30	46 53 17.85		
7	Rowse	79 24 49.15	47.47	2,225.37	306 17 38.40	37 03 34.67	89 15 27.87
		05.19	00.01				
6	Dickey	84 45 43.33	43.71	1,511.30	46 53 17.85		
7	Rowse	61 16 55.57	55.08	2,694.42	165 35 55.85		
8	Murray	33 57 20.12	21.22	2,372.91	311 38 18.28	37 04 59.32	89 15 55.00
		59.02	00.01				
7	Rowse	33 24 07.12	06.37	2,694.42	165 35 55.85		
8	Murray	86 09 12.54	13.43	1,705.18	71 44 52.92		
9	Missouri Sister	60 26 40.00	40.21	3,090.50	312 10 53.60	37 04 41.99	89 17 00.56
		59.66	00.01				
8	Murray	35 17 40.47	40.71	1,705.18	71 44 52.92		
9	Missouri Sister	116 21 33.05	33.02	2,075.03	135 22 40.37		
10	Spiese's Mill	28 20 44.54	46.27	3,217.98	287 01 18.52	37 05 29.90	89 17 59.58
		58.06	00.00				
9	Missouri Sister	57 55 51.00	52.17	2,075.03	135 22 40.37		
10	Spiese's Mill	68 25 11.05	13.33	2,183.28	23 47 18.12		
11	Scudder	53 38 52.82	54.51	2,395.83	257 25 51.13	37 04 25.09	89 18 35.23
		54.96	00.01				
10	Spiese's Mill	58 17 21.17	20.01	2,183.28	23 47 18.12		
11	Scudder	91 36 10.07	08.19	3,702.50	112 10 48.43		
12	Promised Land	30 06 33.02	31.82	4,350.55	262 02 52.91	37 05 10.41	89 20 54.05
		04.26	00.02				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longi
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	°
10	Spiese's Mill	34 35 25.66	25.71	4,350.55	82 04 38.13	....	......
12	Promised Land	115 14 33.92	33.71	4,914.90	146 48 19.20	....	......
13	Atherton	30 09 59.13	00.63	7,830.76	296 37 12.82	37 07 22.82	89 22
		58.71	00.05				
12	Promised Land	42 27 04.71	04.94	4,914.90	146 48 19.20	....	......
13	Atherton	39 52 28.35	30.01	3,347.36	6 39 43.46	....	......
14	Goose Island	97 40 24.41	25.08	3,179.49	284 19 59.04	37 05 35.96	89 22
		57.47	00.03				
13	Atherton	84 57 52.40	53.52	3,347.36	6 39 43.46	....	......
14	Goose Island	42 50 35.04	34.73	4,220.43	143 48 50.23	....	......
15	Powers Island	52 11 31.22	31.77	2,880.98	271 36 26.57	37 07 26.46	89 24
		58.66	00.02				
13	Atherton	36 03 01.16	01.24	2,880.98	91 37 36.98	....	......
15	Powers Island	86 28 50.35	50.12	2,010.96	185 07 36.45	....	......
16	Burnham	57 28 07.66	08.65	3,410.67	307 39 32.19	37 08 31.43	89 24
		59.17	00.01				
15	Powers Island	55 54 42.28	42.91	2,010.96	185 07 36.45	....	......
16	Burnham	82 06 10.50	11.35	2,480.67	87 13 52.19	....	......
17	Commerce	41 59 57.30	57.75	2,977.70	309 11 57.11	37 08 27.52	89 26
		50.08	00.01				
16	Burnham	67 08 44.96	44.20	2,480.67	87 13 52.19	....	......
17	Commerce	67 08 10.64	20.15	3,204.80	200 04 31.20	....	......
18	Santa Fé	45 42 51.78	52.67	3,204.63	334 22 04.47	37 10 05.16	89 25
		56.38	00.02				
17	Commerce	43 31 21.05	20.33	3,204.80	200 04 31.20	....	......
18	Santa Fé	70 07 32.83	33.52	2,400.26	90 12 31.65	....	......
19	Hofner	66 21 06.20	06.17	3,290.22	330 32 38.53	37 10 05.44	89 27
		00.08	00.02				
18	Santa Fé	57 36 48.20	48.26	2,400.26	90 12 31.65	....	......
19	Hofner	56 41 32.73	32.16	2,282.38	213 30 00.50	....	......
20	Lassar	65 41 39.04	39.50	2,200.38	327 48 51.00	37 11 05.80	89 26
		59.97	00.01				
19	Hofner	58 12 37.53	37.72	2,282.38	213 30 00.50	....	......
20	Lassar	83 40 18.54	19.91	3,074.00	117 10 50.50	....	......
21	Uncle Joe	38 07 01.33	02.39	3,504.48	335 16 45.93	37 11 51.36	89 26
		57.40	00.02				
20	Lassar	33 42 06.83	06.24	3,074.00	117 10 50.50	....	......
21	Uncle Joe	70 55 14.77	13.95	1,762.76	226 14 29.61	....	......
22	Thebes	75 22 39.61	39.82	3,002.37	330 52 21.01	37 12 30.91	89 27
		01.21	00.01				
21	Uncle Joe	59 09 28.69	28.66	1,762.76	226 14 29.61	....	......
22	Thebes	72 33 18.93	20.10	2,027.48	118 48 20.93	....	......
23	Grand Chain	48 17 10.61	11.25	2,252.82	347 04 48.00	37 13 02.50	89 28
		58.23	00.01				
22	Thebes	61 30 41.12	42.17	2,027.48	118 48 20.93	....	......
23	Grand Chain	73 28 01.25	01.63	2,519.18	225 19 35.71	....	......
24	Day	45 01 14.45	16.21	2,747.74	00 19 03.47	37 14 00.04	89 27 1
		56.82	00.01				
22	Thebes	28 09 43.49	42.86	2,747.74	180 19 03.10	....	......
24	Day	75 06 60.28	59.65	1,332.46	75 26 08.12	....	......
24′	South Base	76 43 18.12	17.49	2,728.50	332 08 48.96	37 13 49.17	89 28 0
		01.89	00.00				
24	Day	58 51 29.88	29.71	1,332.46	75 26 08.12	....	......
24′	South Base	54 16 54.38	54.20	1,240.22	201 08 37.37	....	......
24″	North Base	66 51 36.26	36.09	1,176.47	314 17 15.89	37 14 26.60	89 27 4
		00.52	00.00				
23	Grand Chain	36 22 39.32	39.30	2,519.18	225 19 35.71	....	......
24	Day	97 25 38.45	39.97	2,070.31	142 45 59.65	....	......
25	Cape Lacroix	46 11 39.71	40.74	3,461.35	8 57 09.63	37 14 53.51	89 28 0
		57.48	00.01				
24	Day	58 40 03.66	03.26	2,070.31	142 45 59.65	....	......
25	Cape Lacroix	62 40 45.80	47.41	2,070.64	260 04 41.47	....	......
26	Sexton's	58 39 07.10	09.33	2,153.77	21 26 22.24	37 15 05.07	89 26 4
		56.56	00.00				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
25	Cape Lacroix	83 07 19.71	18.71	2,070.64	260 04 41.47	....	....
26	Sexton's	86 04 18.03	14.68	10,963.46	166 09 46.26	....	....
27	Floral	10 48 24.28	26.66	11,016.98	356 57 08.36	37 20 50.38	89 28 29.53
		02.02	00.05				
26	Sexton's	46 56 12.61	10.74	10,963.46	166 09 46.26	....	....
27	Floral	65 08 54.01	52.96	8,644.05	280 59 48.75	....	....
28	Clear Creek	67 54 56.38	56.52	10,735.88	33 08 21.30	37 19 56.75	89 22 44.84
		03.00	00.22				
27	Floral	46 41 44.33	42.94	8,644.05	280 59 48.75	....	....
28	Clear Creek	95 52 55.53	55.47	10,351.34	100 53 13.28	....	....
29	Bluff Lake	37 25 22.20	21.82	14,149.53	54 22 49.55	37 25 17.94	89 20 42.20
		02.06	00.23				
28	Clear Creek	45 36 26.92	26.69	10,351.34	196 56 13.28	....	....
29	Bluff Lake	85 49 16.72	17.85	9,865.18	102 46 45.58	....	....
30	Moccasin Springs	48 34 15.11	15.72	13,769.21	331 17 03.42	37 26 28.54	89 27 13.57
		58.75	00.26				
29	Bluff Lake	38 58 55.32	56.36	9,865.18	102 46 45.58	....	....
30	Moccasin Springs	89 10 21.69	22.39	7,892.25	103 32 25.31	....	....
31	Rich	51 50 39.49	41.45	12,514.78	321 42 29.04	37 30 37.42	89 25 58.33
		56.50	00.20				
30	Moccasin Springs	42 46 36.39	36.66	7,892.25	103 32 25.31	....	....
31	Rich	82 26 58.37	60.05	6,561.56	96 00 11.14	....	....
32	Indian Creek	54 46 22.35	23.42	9,877.75	330 43 52.75	37 30 59.60	89 30 24.06
		57.11	00.13				
31	Rich	49 40 11.50	11.31	6,561.56	96 00 11.14	....	....
32	Indian Creek	102 12 07.34	06.61	10,609.97	173 45 22.72	....	....
33	Silica	28 07 41.20	42.25	13,603.45	325 37 11.79	37 36 41.72	89 31 11.11
		00.04	00.17				
32	Indian Creek	49 50 51.61	50.11	10,609.97	173 45 22.72	....	....
33	Silica	55 37 47.49	45.46	8,414.61	298 07 08.58	....	....
34	Big Muddy	74 31 25.60	24.62	9,086.99	43 38 48.47	37 34 32.97	89 26 08.67
		04.70	00.19				
33	Silica	107 18 01.20	01.48	8,414.61	298 07 08.58	....	....
34	Big Muddy	38 22 06.69	07.74	14,245.30	156 32 20.83	....	....
35	Fountain Bluff	34 19 50.18	50.97	9,261 35	10 49 50.45	37 41 36.77	89 30 00.16
		58.07	00 19				
34	Big Muddy	35 09 37.54	38.60	14,245.30	156 32 20.83	....	....
35	Fountain Bluff	65 21 15.42	16.20	8,343.58	271 08 43.28	....	....
36	Swallow Rock	79 29 03.67	05.47	13,168.78	11 43 05.99	37 41 31.23	89 24 19.67
		56.63	00.27				
35	Fountain Bluff	75 43 59.24	59.09	8,343.58	271 08 43.28	....	....
36	Swallow Rock	54 17 47.80	48.24	10,560.46	145 29 59.70	....	....
37	Worthen	49 58 11.70	12.85	8,848 50	15 25 42.99	37 46 13.45	89 28 24.07
		58.74	00.18				
35	Fountain Bluff	83 11 18.03	17.47	8,848.50	105 24 44.10	....	....
37	Worthen	65 49 39.68	40.26	17,066.99	81 15 23.25	....	....
38	Backbone	30 59 00.62	02.62	15,681.23	292 07 23.96	37 44 48.74	89 39 53.09
		58.33	00.35				
37	Worthen	29 46 57.20	57.79	17,066.99	81 15 23.25	....	....
38	Backbone	69 23 07.65	06.55	8,587.07	191 45 14.79	....	....
39	O'Harrah	80 49 57.19	56.01	16,180.86	290 56 02.60	37 49 21.42	89 38 41.57
		02.04	00.35				
38	Backbone	72 28 46.17	47.92	8,587.07	191 45 14.79	....	....
39	O'Harrah	68 39 58.40	60.42	13,053.34	80 25 59.04	....	....
40	Killion	38 51 11.69	11.92	12,750.30	299 11 48.38	37 48 10.73	89 47 27.73
		56.26	00.26				
39	O'Harrah	87 54 52.30	52.99	13,053.34	80 25 59.04	....	....
40	Killion	49 42 14.13	18.58	8,028.04	210 38 17.88	....	....
41	Manskear	92 22 45.92	48.63	9,962.43	298 17 11.91	37 51 54.74	89 44 40.35
		52.35	00.20				
40	Killion	36 32 10.16	14.62	8,028.04	210 38 17.88	....	....
41	Manskear	50 19 06.08	05.64	4,786.68	340 20 54.90	....	....
41′	Lower Base	93 08 39.10	39.82	6,187.72	67 12 55.46	37 49 28.52	89 43 34.58
		55.43	00.08				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longit
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′
40	Killion	31 27 43.01	44.26	6,187.72	247 10 32.49		
41′	Lower Base	65 42 35.84	36.41	3,255.07	132 55 31.86		
41″	Upper Base	82 49 37.48	39.38	5,684.44	35 44 11.45	37 50 40.41	89 45
		56.33	00.05				
40	Killion	40 08 30.09	28.32	8,024.04	210 38 17.88		
41	Manskear	94 20 30.40	28.53	7,253.98	125 00 29.07		
42	Chester	45 31 03.67	03.30	11,219.89	350 29 03.03	37 54 09.65	89 48
		04.16	00.15				
40	Killion	48 41 53.59	55.01	11,219 89	170 29 49.56		
42	Chester	74 08 16.48	16.32	10,031.77	64 37 19.35		
43	Rozier	57 09 47.76	48.94	12,845.01	301 43 20.60	37 51 50.03	89 54
		57.83	00.27				
42	Chester	29 49 27.47	28.75	10,031.77	64 37 19.35		
43	Rozier	114 20 18.69	19.37	8,521.73	130 13 12.29		
44	Vanse	35 50 10.80	12.08	15,611.56	274 20 16.62	37 54 48.43	89 59
		56.96	00.20				
43	Rozier	53 15 22.23	22.14	8,521.73	130 13 12.29		
44	Vanse	78 03 51.68	51.00	9,092.33	232 06 37.69		
45	Kaskaskia	48 40 47.14	47.05	11,101.40	3 28 51.37	37 57 49.43	89 54
		01.05	00.19				
44	Vanse	50 42 30.88	31.92	9,092.33	232 06 37.69		
45	Kaskaskia	83 48 33.79	35.43	9,869.12	135 58 13.85		
46	Reagan	45 28 51.24	52.88	12,677.47	1 24 13.60	38 01 39.48	89 59
		55.91	00.23				
44	Vanse	39 27 22.73	21.59	12,677.47	181 24 05.78		
46	Reagan	73 38 02.33	01.78	8,757.93	75 02 15.38		
47	Correll	66 54 38.04	36.90	13,223.07	321 53 18.67	38 00 26.00	90 04
		03.10	00.27				
46	Reagan	44 46 36.92	38.01	8,757.93	75 02 15.38		
47	Correll	54 11 06.79	07.29	6,244.91	200 47 34.48		
48	Brewerville	81 02 13.72	14.81	7,189.71	299 46 15.70	38 03 35.35	90 03
		57.43	00.11				
47	Correll	73 19 06.22	06.65	6,244.91	200 47 34.48		
48	Brewerville	57 17 38.95	39.97	7,880.26	78 06 10.47		
49	Magnolia	49 23 12.47	13.49	6,922.23	307 26 09.04	38 02 42.54	90 08
		57.64	00.11				
47	Correll	35 25 13.94	14.64	6,922.23	127 28 27.83		
49	Magnolia	112 52 41.02	41.10	7,634.70	194 33 27.94		
50	County Line	31 42 03.69	04.38	12,136.64	342 52 12.14	38 06 42.21	90 07
		58.65	00.12				
49	Magnolia	67 09 09.98	09.40	7,634.70	194 33 27.94		
50	County Line	56 24 08.98	09.01	8,442.63	70 58 25.53		
51	Brickey	56 26 42.32	41.73	7,630.95	307 21 45.18	38 05 12.82	90 12
		01.28	00.14				
50	County Line	58 41 09.09	08.79	8,442.63	70 58 25.53		
51	Brickey	72 16 13.48	12.34	9,550.64	178 38 51.10		
52	Kidd	49 02 38.69	39.06	10,648.12	309 36 06.32	38 10 22.49	90 12
		01.26	00.19				
51	Brickey	43 00 37.90	37.55	9,550.64	178 38 51.10		
52	Kidd	81 49 55.06	56.27	7,937.86	80 28 41.65		
53	Cæsar's	55 09 25.90	26.37	11,518.81	315 34 49.31	38 09 39.78	90 18
		58.86	00.19				
52	Kidd	65 19 59.21	58.27	7,937.86	80 28 41.65		
53	Cæsar's	62 59 02.25	00.69	9,193.88	197 26 22.25		
54	Weisenborn	51 41 02.16	01.20	9,013.07	325 46 31.12	38 14 24.24	90 16
		03.62	00.16				
53	Cæsar's	46 32 53.42	54.70	9,193.88	197 26 22.25		
54	Weisenborn	83 16 02.46	04.36	8,689.44	100 43 36.68		
55	Herculaneum	50 10 59.87	61.14	11,887.10	330 51 00.44	38 15 16.55	90 22 17.
		55.75	00.20				
54	Weisenborn	61 59 42.94	43.04	8,689.44	100 43 36.68		
55	Herculaneum	55 46 00.56	00.03	8,069.98	224 53 59.27		
56	Salt Bluff	62 14 17.00	17.09	8,118.54	342 42 18.24	38 18 35.65	90 18 05.
		00.50	00.16				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
55	Herculaneum	47 20 16.23	16.48	8,609.98	224 53 50.27	....	....
56	Salt Bluff	62 24 32.64	33.50	6,773.94	107 21 08.83	....	....
57	Sulphur Springs	70 15 09.91	10.15	8,164.13	357 33 33.93	38 19 41.09	90 22 31.84
		58.78	00.13				
56	Salt Bluff	61 00 22.41	24.59	6,773.94	107 21 08.83	....	....
57	Sulphur Springs	81 19 49.20	51.50	9,697.15	205 58 32.28	....	....
58	Meramec	37 39 43.94	44.07	10,959.69	348 20 36.86	38 24 23.78	90 19 36.79
		55.55	00.16				
56	Salt Bluff	39 36 46.72	45.92	10,959.89	168 21 33.42	....	....
58	Meramec	43 33 15.72	14.73	7,037.96	304 47 22.13	....	....
59	Becan	96 49 60.52	59.49	7,605.82	27 59 50.50	38 22 13.48	90 15 38.69
		03.02	00.14				
58	Meramec	50 52 43.93	43.67	7,037.96	304 47 22.13	....	....
59	Becan	78 36 30.82	31.15	7,074.89	203 26 21.14	....	....
60	Gummershimer	50 30 45.56	45.30	8,930.68	73 58 18.51	38 25 43.98	90 13 42.67
		00.31	00.12				
59	Becan	41 07 51.06	51.46	7,074.89	203 26 21.14	....	....
60	Gummershimer	90 22 19.62	20.62	6,213.95	113 49 53.82	....	....
61	Twin Hollow	48 29 47.63	48.03	9,446.62	342 17 16.12	38 27 05.35	90 17 37.08
		58.31	00.11				
60	Gummershimer	83 55 59.62	60.73	6,213.95	113 49 53.82	....	....
61	Twin Hollow	67 48 55.88	56.39	9,080.80	235 58 31.70	....	....
62	Dryer	38 15 02.50	03.01	8,494.69	17 47 01.09	38 30 06.33	90 11 55.71
		58.00	00.13				
60	Gummershimer	49 12 45.46	45.76	8,494.69	197 45 54.55	....	....
62	Dryer	79 24 46.99	47.88	8,232.67	97 11 48.97	....	....
63	Ferder	51 22 26.24	20.53	10,688.27	328 30 45.61	38 30 39.64	90 17 32.83
		58.69	00.17				
62	Dryer	51 05 01.70	01.86	8,232.67	97 11 48.97	....	....
63	Ferder	90 46 60.43	59.90	10,373.58	186 21 19.09	....	....
64	Insane Asylum	38 07 58.81	58.37	13,331.28	328 13 50.30	38 36 13.09	90 16 45.37
		60.94	00.22				
62	Dryer	84 03 52.01	53.73	13,331.28	148 16 50.83	....	....
64	Insane Asylum	49 47 09.37	09.19	18,387.10	278 26 41.11	....	....
65	Clark's Mound	46 08 56.56	57.55	14,1[illegible]6.73	52 25 32.25	38 34 45.75	90 04 13.97
		57.94	00.47				
64	Insane Asylum	58 44 17.72	17.70	18,387.10	278 26 41.11	....	....
65	Clark's Mound	31 29 45.00	45.03	15,717.51	130 04 14.84	....	....
66	Stand Pipe	89 45 57.62	57.65	9,606.16	39 45 01.92	38 40 13.59	90 12 31.51
		00.34	00.38				
65	Clark's Mound	71 47 17.06	18.51	15,717.51	130 04 14.84	....	....
66	Stand Pipe	51 12 27.59	28.44	17,801.48	258 46 35.83	....	....
67	Sugar Loaf	57 00 12.78	13.60	14,666.50	21 53 53.89	38 42 05.33	90 00 28.91
		58.33	00.55				
66	Stand Pipe	68 30 09.14	08.15	17,801.48	258 46 35.83	....	....
67	Sugar Loaf	33 08 35.94	36.81	16,911.19	112 02 44.30	....	....
68	Robinson	78 21 16.07	15.46	9,937.31	10 17 13.50	38 45 30.68	90 11 18.10
		01.15	00.42				
66	Stand Pipe	35 09 57.67	57.38	9,937.31	190 16 27.68	....	....
68	Robinson	48 28 12.54	12.36	5,758.84	321 49 01.23	....	....
69	Soechtig	96 21 50.56	50.37	7,485.29	45 28 43.07	38 43 03.85	90 08 50.74
		00.77	00.11				
68	Robinson	73 34 35.54	36.97	5,758.84	321 49 01.23	....	....
69	Soechtig	38 11 55.30	55.63	5,948.35	180 02 30.08	....	....
70	Pettingill	68 13 24.98	26.45	3,834.90	68 15 56.64	38 46 16.76	90 08 50.56
		55.82	00.05				
68	Robinson	33 07 51.71	51.80	3,834.90	248 14 24.26	....	....
70	Pettingill	107 58 35.98	36.21	3,338.31	170 14 32.85	....	....
71	Terrapin	38 53 31.69	32.02	5,809.73	35 07 59.19	38 48 04.79	90 08 59.63
		59.38	00.03				
70	Pettingill	40 06 31.22	32.68	3,338.31	176 14 32.85	....	....
71	Terrapin	88 23 24.31	25.86	2,748.09	267 51 01.31	....	....
72	Moore	51 29 59.86	61.48	4,263.92	36 22 11.14	38 48 08.12	90 07 03.82
		55.39	00.02				

Tabulated results of secondary triangulation from Cairo to Keokuk—Contin

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	L
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	
71	Terrapin	30 24 58.64	58.44	2,748.09	267 51 01.31		
72	Moore	45 18 14.17	14.11	1,435.66	133 10 26.73		
73	Missouri River	104 16 47.54	47.46	2,015.76	57 26 46.99	38 48 39.97	[illegible]
		00.35	00.01				
72	Moore	63 29 37.60	36.82	1,435.66	133 10 26.73		
73	Missouri River	86 14 42.46	41.73	2,549.36	226 55 17.81		
74	Gillan	30 15 42.05	41.46	2,842.70	16 40 24.74	38 49 36.43	[illegible]
		02.11	00.01				
73	Missouri River	37 32 38.94	38.88	2,549.36	226 55 17.81		
74	Gillan	104 29 09.23	09.27	2,525.02	151 25 15.47		
75	Shirley	37 58 11.71	11.87	4,011.91	9 22 55.92	38 50 48.33	[illegible]
		59.88	00.02				
74	Gillan	32 00 57.88	58.43	2,525.02	151 25 15.47		
75	Shirley	65 34 18.65	19.34	1,350.49	265 50 24.72		
76	Gesler	82 24 41.55	42.24	2,319.29	3 26 17.52	38 50 51.51	[illegible]
		58.08	00.01				
75	Shirley	111 01 06.72	07.26	1,350.49	265 50 24.72		
76	Gesler	36 48 03.92	04.61	2,367.02	122 39 04.36		
77	Ringering	32 10 47.67	48.14	1,519.01	334 49 00.65	38 51 32.91	[illegible]
		58.31	00.01				
75	Shirley	37 04 16.14	16.83	1,519.01	154 49 17.46		
77	Ringering	111 41 31.95	32.49	1,765.77	86 30 33.14		
78	Freeman	31 14 09.32	10.69	2,721.80	297 43 57.97	38 51 29.42	[illegible]
		57.41	00.01				
77	Ringering	58 13 15.31	14.81	1,765.77	86 30 33.14		
78	Freeman	72 01 60.25	59.82	1,966.83	194 27 47.46		
79	Russell	49 44 45.76	45.38	2,200.86	324 43 14.86	38 52 31.18	[illegible]
		01.32	00.01				
78	Freeman	48 05 30.53	29.11	1,966.83	194 27 47.46		
79	Russell	97 14 58.68	57.34	2,573.85	111 42 57.58		
80	Glass Works	34 39 34.78	33.56	3,430.84	326 21 28.88	38 53 02.06	90
		03.99	00.01				
79	Russell	37 16 43.81	43.39	2,573.85	111 42 57.58		
80	Glass Works	82 10 49.50	49.18	1,790.45	13 52 44.50		
81	Watkins	60 32 27.70	27.44	2,928.55	254 25 00.76	38 52 05.69	90
		01.01	00.01				
80	Glass Works	72 15 44.93	45.25	1,790.45	13 52 44.50		
81	Watkins	61 22 25.59	25.85	2,356.31	132 30 07.46		
82	Strong	46 21 48.51	48.91	2,171.51	266 07 33.32	38 52 57.31	90
		59.03	00.01				
80	Glass Works	30 10 34.97	35.94	2,171.51	86 08 29.75		
82	Strong	66 47 50.15	51.25	1,099.69	199 19 42.07		
83	Alton	83 01 31.69	32.82	2,010.75	296 18 18.73	38 53 30.96	90
		56.81	00.01				
82	Strong	34 06 46.40	44.83	1,099.69	199 19 42.07		
83	Alton	112 32 09.62	09.18	1,121.77	131 52 00.73		
84	Saw Mill	33 21 04.85	05.99	1,847.50	345 12 44.95	38 53 55.24	90
		00.87	00.00				
82	Strong	29 31 16.35	15.08	1,847.50	165 12 57.24		
84	Saw Mill	111 25 50.62	52.13	1,445.05	96 38 37.08		
85	Nicholson	39 02 52.32	52.80	2,729.91	315 40 52.48	38 54 00.65	90
		59.29	00.01				
84	Saw Mill	36 39 16.09	15.86	1,445.05	96 38 37.08		
85	Nicholson	100 17 57.97	57.84	1,263.83	176 20 01.84		
86	Hop Hollow	43 02 46.33	46.30	2,082.90	313 17 13.43	38 54 41.55	90
		00.39	00.00				
85	Nicholson	63 11 33.17	33.85	1,263.83	176 20 01.84		
86	Hop Hollow	30 17 47.36	47.02	1,895.88	76 37 46.75		
87	Weper	86 30 38.33	39.14	2,093.78	293 07 37.81	38 54 27.33	90
		58.86	00.01				
86	Hop Hollow	47 36 04.34	01.50	1,895.88	76 37 46.75		
87	Weper	56 43 03.61	03.06	1,444.92	199 53 55.61		
88	Hull	75 40 58.03	55.44	1,635.72	304 13 12.99	38 55 11.39	90
		05.98	00.00				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
87	Weper	86 46 56.95	57.84	1,444.92	199 53 55.61	....	....
88	Hull	62 29 11.24	12.13	2,823.16	82 23 20.56	....	....
89	Barwise	30 43 49.01	50.04	2,507.82	293 05 57.63	38 54 59.25	90 16 05.50
		57.20	00.01				
88	Hull	35 00 16.85	14.33	2,823.16	82 23 20.56	....	....
89	Barwise	102 36 47.39	45.00	2,402.44	159 45 22.59	....	....
90	Reihl	42 23 03.00	00.69	4,087.04	297 22 00.21	38 56 12.34	90 16 40.01
		07.24	00.02				
89	Barwise	41 11 36.23	35.61	2,402.44	159 45 22.59	....	....
90	Reihl	105 46 02.28	01.76	2,902.04	85 31 02.66	....	....
91	Eagle's Nest	33 02 23.04	22.65	4,240.58	298 32 09.82	38 56 04.97	90 18 40.13
		01.55	00.02				
90	Reihl	37 59 22.39	22.85	2,902.04	85 31 02.66	....	....
91	Eagle's Nest	103 11 27.69	28.26	2,849.52	8 41 15.43	....	....
92	Echele	38 49 08.25	08.91	4,507.30	227 30 13.12	38 54 33.62	90 18 58.00
		58.33	00.02				
91	Eagle's Nest	50 51 30.83	29.13	2,849.52	8 41 15.43	....	....
92	Echele	73 11 21.10	19.46	2,667.27	115 29 44.75	....	....
93	Portage	55 57 13.01	11.43	3,292.06	239 31 30.55	38 55 10.84	90 20 37.93
		04.94	00.02				
92	Echele	39 45 07.65	07.09	2,667.27	115 29 44.75	....	....
93	Portage	97 54 14.82	14.35	2,532.17	197 34 27.63	....	....
94	Starr	42 20 38.94	38.58	3,922.21	335 14 08.99	38 56 29.12	90 20 06.18
		01.41	00.02				
93	Portage	85 44 45 08	45.82	2,532.17	197 34 27.63	....	....
94	Starr	52 21 28.20	27.97	3,781.47	69 56 15.54	....	....
95	Pourie	41 53 44.83	46.23	3,002.59	291 48 29.10	38 55 47.03	90 22 33.65
		58.11	00.02				
94	Starr	48 06 02.76	02.90	3,781.47	69 56 15.54	....	....
95	Pourie	58 48 22.80	22.53	2,941.78	191 06 20.33	....	....
96	Elsah	73 05 35.04	34.59	3,380.88	298 01 00.53	38 57 20.64	90 22 10.12
		00.60	00.02				
95	Pourie	80 14 53.69	54.81	2,941.78	191 06 20.33	....	....
96	Elsah	66 17 00.09	01.21	5,257.37	77 23 36.33	....	....
97	East Base	33 28 02.76	04.02	4,883.94	290 49 26.42	38 56 43.38	90 25 43.16
		56.54	00.04				
96	Elsah	27 29 05.73	06.27	5,257.37	77 23 36.33	....	....
97	East Base	111 21 34.13	34.83	3,686.92	145 59 47.57	....	....
98	Grafton	41 09 18.15	18.95	7,439.97	284 49 34.76	38 58 22.48	90 27 08.82
		58.01	00.05				
97	East Base	82 11 48.38	48.09	3,686.92	145 59 47.57	....	....
98	Grafton	30 32 38.83	37.61	3,960.66	356 31 31.32	....	....
99	West Base	67 15 33.10	34.32	2,031.61	243 47 11.91	38 56 14.28	90 26 58.85
		59.81	00.02				
98	Grafton	93 13 05.97	06.27	3,960.66	356 31 31.32	....	....
99	West Base	41 18 38.26	39.24	5,547.00	135 12 58.34	....	....
100	Rivermouth	45 28 14.35	14.53	3,667.61	269 43 01.77	38 58 21.92	90 29 41.17
		58.58	00.04				
99	West Base	67 19 11.20	11.22	5,547.00	135 12 58.34	....	....
100	Rivermouth	68 37 51.04	49.77	7,361.12	23 49 06.07	....	....
101	Point Landing	44 02 58.92	59.11	7,429.57	247 50 47.62	38 54 43.53	90 31 44.55
		01.16	00.10				
100	Rivermouth	75 30 15.96	15.48	7,361.12	23 49 06.07	....	....
101	Point Landing	31 55 21.75	22.22	7,469.66	171 52 26.29	....	....
102	Thompson	72 34 22.54	22.37	4,079.65	279 17 36.35	38 58 43.32	90 32 28.42
		00.25	00.07				
101	Point Landing	63 56 41.36	41.85	7,469.66	171 52 26.29	....	....
102	Thompson	34 59 37.55	37.49	6,793.04	26 51 36.21	....	....
103	Calhoun	81 03 39.90	40.73	4,336.42	287 53 56.85	38 55 26.78	90 34 35.83
		58.81	00.07				
102	Thompson	63 31 32.71	31.48	6,793.04	26 51 36.21	....	....
103	Calhoun	60 15 45.06	45.77	7,316.41	146 34 30.35	....	....
104	Droege	56 12 43.34	42.86	7,007.16	270 20 02.23	38 58 44.77	90 37 23.26
		01.11	00.11				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longi
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′
103	Calhoun	32 57 50.07	50.23	7,316.41	146 34 30.35	....	......
104	Droege	70 02 56.18	55.10	4,085.86	36 35 40.19	....	......
105	Keel	76 59 14.53	14.74	7,058.55	293 33 51.32	38 56 58.38	90 38
		00.78	00.07				
104	Droege	69 22 37.25	37.08	4,085.86	36 35 40.19	....	......
105	Keel	58 46 31.04	31.87	4,862.89	157 48 04.71	....	......
106	Cahill	51 50 50.64	51.09	4,443.20	285 56 25.61	38 59 24.38	90 46
		58.93	00.04				
105	Keel	38 06 12.65	11.93	4,862.89	157 48 04.71	....	......
106	Cahill	110 23 29.33	28.49	5,742.28	88 10 45.19	....	......
107	Winfield	31 30 18.81	19.65	8,722.42	299 38 34.80	38 59 18.39	90 44
		00.79	00.07				
106	Cahill	88 53 44.86	44.32	5,742.28	88 10 45.19	....	......
107	Winfield	44 26 45.67	45.41	7,898.57	223 41 29.74	....	......
108	Wilson	46 37 29.57	30.35	5,531.83	357 06 22.20	39 02 23.54	90 46
		00.10	00.08				
106	Cahill	55 10 00.17	00.16	5,531.83	177 06 29.51	....	......
108	Wilson	80 44 14.40	13.96	6,525.16	77 50 36.16	....	......
109	Kilham	44 05 45.05	45.97	7,845.93	301 53 35.12	39 01 38.90	90 44
		59.62	00.09				
108	Wilson	109 36 25.36	23.72	6,525.16	77 50 36.16	....	......
109	Kilham	37 30 52.59	52.37	11,322.93	220 16 56.78	....	......
110	Peets	32 52 44.64	44.02	7,319.65	7 27 24.78	39 06 18.90	90 39
		02.59	00.11				
109	Kilham	47 50 36.15	34.93	11,322.93	220 16 56.78	....	......
110	Peets	42 29 26.50	26.63	8,393.93	82 49 35.43	....	......
111	Knox	89 39 58.85	58.61	7,648.44	352 25 55.46	39 05 44.76	90 45
		01.50	00.17				
110	Peets	79 33 48.23	48.07	8,393.93	82 49 35.43	....	......
111	Knox	69 20 02.13	01.86	15,980.34	193 25 54.99	....	......
112	Hamburg	31 06 10.62	10.39	15,203.58	342 21 22.36	39 14 08.76	90 43
		00.98	00.32				
111	Knox	31 25 42.49	40.65	15,980.34	193 25 54.99	....	......
112	Hamburg	88 55 29.94	30.19	9,656.13	102 23 02.94	....	......
113	Saltpeter	59 38 48.15	49.55	18,515.46	341 57 43.64	39 15 15.73	90 49
		00.58	00.39				
112	Hamburg	53 01 33.22	32.50	9,656.13	102 23 02.94	....	......
113	Saltpeter	89 21 55.07	56.55	12,640.96	192 56 57.54	....	......
114	Belleview	37 36 30.56	31.26	15,821.88	335 21 41.24	39 21 55.20	90 47
		58.85	00.31				
113	Saltpeter	41 23 36.16	37.72	12,640.96	192 56 57.54	....	......
114	Belleview	82 13 05.78	04.66	10,036.63	95 11 17.16	....	......
115	Clarksville	56 23 17.90	17.94	15,038.92	331 30 10.22	39 22 24.42	90 54
		59.84	00.32				
114	Belleview	43 38 49.53	47.84	10,036.63	95 11 17.16	....	......
115	Clarksville	100 53 45.52	45.19	11,941.68	174 13 07.09	....	......
116	Long	35 27 27.66	27.27	16,989.65	318 45 07.86	39 28 49.67	90 55
		02.71	00.30				
115	Clarksville	46 44 26.79	25.51	11,941.68	174 13 07.09	....	......
116	Long	89 57 35.99	39.56	12,680.93	84 10 14.69	....	......
117	Salt River	43 17 55.19	55.31	17,412.73	307 22 34.49	39 28 07.58	91 04
		57.97	00.38				
116	Long	46 03 22.94	25.58	12,680.93	84 10 14.69	....	......
117	Salt River	44 24 05.39	05.28	9,130.96	308 28 44.46	....	......
118	McLean	89 32 28.79	29.35	8,872.89	218 04 23.65	39 25 03.24	90 59
		57.12	00.21				
117	Salt River	61 16 28.52	28.32	9,130.96	308 28 44.46	....	......
118	McLean	30 00 55.61	56.03	8,009.27	158 32 50.33	....	......
119	Inner Base	88 42 35.69	35.74	4,568.79	67 14 08.18	39 29 04.94	91 01
		59.82	00.00				
117	Salt River	34 55 30.33	29.02	4,568.79	247 12 16.14	....	......
119	Inner Base	40 17 52.28	52.54	2,705.10	26 56 15.64	....	......
120	Outer Base	104 46 39.16	38.46	3,056.00	102 09 04.63	39 27 46.74	91 02
		01.77	00.02				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters*	° ′ ″	° ′ ″	° ′ ″
118	McLean	30 49 13.08	13.98	8,0[illegible]9.27	158 32 50.33		
119	Inner Base	62 14 05.84	06.74	4,109.40	40 45 39.18		
121	Louisiana	86 56 38.44	39.35	7,097.23	307 41 07.19	39 27 23.99	91 03 11.31
		57.36	00.07				
117	Salt River	100 00 02.93	01.90	9,130.96	308 28 44.46		
118	McLean	41 50 56.36	55.41	14,556.82	170 22 49.71		
122	Rockport	38 09 05.13	02.92	9,861.65	28 30 47.88	39 32 48.61	91 00 58.40
		04.42	00.23				
117	Salt River	67 05 14.0[illegible]	13.73	9,861.65	208 28 42.59		
122	Rockport	83 16 03.87	04.61	18,364.53	111 46 52.49		
123	Red House	29 38 42.67	42.08	19,800.18	321 17 59.16	39 36 28.96	91 12 53.24
		00.54	00.42				
122	Rockport	32 05 49.55	50.16	18,364.53	111 46 52.49		
123	Red House	50 46 43.33	42.63	9,834.05	240 52 34.45		
124	Gard	97 07 27.35	27.60	14,337.82	323 48 56.68	39 39 03.99	91 06 52.91
		00.23	00.39				
123	Red House	75 11 46.20	45.78	9,834.05	240 52 34.45		
124	Gard	72 25 22.71	22.62	17,753.07	133 21 46.90		
125	See Horn	32 22 52.17	52.02	17,505.28	345 38 52.52	39 45 38.88	91 15 55.13
		01.08	00.42				
124	Gard	30 07 33.44	32.32	17,753.07	133 21 46.90		
125	See Horn	78 34 44.38	43.79	9,407.05	31 50 44.29		
126	Hannibal	71 17 45.14	44.31	18,371.82	283 06 15.48	39 41 19.73	91 19 23.43
		02.96	00.42				
125	See Horn	70 10 38.64	38.88	9,407.05	31 50 44.29		
126	Hannibal	73 12 38.24	38.24	14,838.64	138 35 52.93		
127	Heather	36 36 42.73	43.22	15,100.88	281 54 46.04	39 47 20.42	91 26 15.86
		59.61	00.34				
126	Hannibal	27 35 52.47	51.68	14,838.64	138 35 52.93		
127	Heather	96 43 16.73	15.92	8,323.07	221 48 13.34		
128	Marble Head	55 40 53.14	52.71	17,842.85	346 09 50.06	39 50 41.52	91 22 22.50
		02.34	00.31				
127	Heather	72 25 15.78	16.3[illegible]	8,323.07	221 48 13.34		
128	Marble Head	63 42 10.74	11.48	11,447.78	105 32 54.25		
129	Nelson	43 52 31.48	32.44	10,765.80	329 20 29.26	39 52 20.76	91 30 06.58
		58.00	00.22				
127	Heather	37 22 08.22	08.67	10,765.80	149 22 57.04		
129	Nelson	105 13 17.54	17.89	10,755.90	224 07 11.37		
130	Quincy	37 24 32.91	33.72	17,[illegible]99.61	6 45 59.99	39 56 31.00	91 24 51.18
		58.67	00.28				
129	Nelson	43 32 53.63	53.35	10,755.90	224 07 11.37		
130	Quincy	103 41 27.95	28.11	13,694.27	147 52 01.82		
131	Lagrange	32 45 38.81	38.90	19,311.85	00 34 23.24	40 02 46.88	91 29 58.45
		00.39	00.36				
130	Quincy	32 14 29.35	28.96	13,694.27	147 52 01.82		
131	Lagrange	119 49 05.49	03.96	15,591.80	207 59 40.38		
132	Lima Lake	27 56 26.82	27.55	25,357.01	00 06 32.09	40 10 13.14	91 24 49.15
		01.66	00.47				
131	Lagrange	43 41 43.43	43.89	15,591.80	207 59 40.38		
132	Lima Lake	38 09 05.75	07.69	10,881.18	66 12 07.33		
133	Canton University	98 09 07.43	08.69	9,730.18	344 16 44.87	40 07 50.57	91 31 49.67
		56.61	00.27				
132	Lima Lake	37 48 27.02	26.92	10,881.18	66 12 07.33		
133	Canton University	60 11 28.45	28.76	[illegible],735.80	185 56 07.42		
134	Cougill	82 00 03.52	04.48	9,534.25	283 56 21.93	40 11 27.78	91 31 20.22
		58.99	00.16				
132	Lima Lake	69 34 55.57	54.98	9,534.25	104 00 34.25		
134	Cougill	74 44 01.99	02.27	15,317.97	209 12 19.66		
135	Gillham	35 41 02.13	03.11	15,768.14	353 34 41.08	40 18 41.16	91 26 03.69
		59.69	00.36				
134	Cougill	22 27 56.66	56.80	15,317.97	209 12 19.66		
135	Gillham	127 07 31.52	32.30	11,564.38	156 23 16.49		
136	Yellow Banks	30 24 30.52	31.26	24,129.02	6 45 40.54	40 24 24.65	91 29 20.13
		58.70	00.36				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longit
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′
135	Gillham	44 10 41.79	42.72	11,564.38	156 23 16.49		
136	Yellow Banks	82 03 42.90	44.26	9,992.28	58 24 53.54		
137	Fox River	53 45 32.14	33.31	14,200.89	292 06 33.13	40 21 34.82	91 35
		56.83	00.29				
136	Yellow Banks	107 55 13.27	14.17	9,992.28	58 24 53.54		
137	Fox River	28 09 47.27	48.19	13,707.39	266 30 48.01		
138	Warsaw	43 54 56.47	57.80	6,799.60	130 32 01.37	40 22 01.44	91 25
		57.01	00.16				
136	Yellow Banks	46 52 40.38	40.85	6,799.60	310 29 39.37		
138	Warsaw	37 44 11.48	12.37	4,985.03	168 16 13.74		
139	Boardman	95 23 06.24	06.83	4,180.04	83 38 52.72	40 24 39.68	91 26
		58.10	00.05				
138	Warsaw	35 52 16.26	16.71	4,985.03	168 16 13.74		
139	Boardman	77 22 15.74	15.86	3,179.06	270 53 30.04		
140	Hughes	66 45 27.24	27.47	5,294.08	24 09 29.96	40 24 38.06	91 24
		59.24	00.04				
138	Warsaw	50 12 55.20	56.15	5,294.08	204 08 30.45		
140	Hughes	67 46 52.56	51.80	4,607.46	316 22 38.16		
141	Worster	62 00 11.21	12.11	5,550.52	74 23 53.38	40 22 49.90	91 21
		58.97	00.06				
138	Warsaw	33 03 35.00	35.09	5,550.52	254 21 26.60		
141	Worster	85 24 20.38	21.69	3,444.29	159 48 15.07		
142	Keokuk	61 32 02.31	03.27	6,293.56	41 19 45.66	40 24 34.70	91 22
		57.69	00.05				
141	Worster	32 37 09.55	09.56	3,444.29	159 48 15.07		
142	Keokuk	48 13 31.78	31.73	1,880.62	291 34 10.66		
143	Hamilton	99 09 18.51	18.72	2,601.80	12 25 40.01	40 24 12.28	91 21
		59.84	00.01				
142	Keokuk	66 28 23.54	24.25	1,880.62	201 34 10.66		
143	Hamilton	55 39 35.20	36.28	2,036.22	167 14 35.01		
144	Rapids	57 51 58.61	59.48	1,833.75	45 06 22.13	40 25 16.66	91 21
		57.35	00.01				
143	Hamilton	38 21 52.69	52.10	2,036.22	167 14 35.01		
144	Rapids	89 15 08.22	08.10	1,595.48	76 29 30.75		
145	Lower Base	52 22 60.12	59.81	2,570.40	308 51 47.89	40 25 04.58	91 22
		01.03	00.01				
144	Rapids	35 35 17.56	18.95	1,595.48	76 29 30.75		
145	Lower Base	98 42 43.06	44.36	1,297.38	157 46 03.70		
146	Upper Base	45 41 54.98	56.69	2,203.60	292 03 53.52	40 25 43.51	91 23
		55.60	00.00				

APPENDIX C.

REPORTS OF ASSISTANT ENGINEERS J. A. PAIGE, J. B. JOHNSON, AND L. L. WHEE UPON THE FIELD-WORK AND REDUCTION OF PRECISE LEVELS BETWEEN CARR TON, LA., AND BILOXI, MISS., AND BETWEEN CAIRO, ILL., AND FULTON, ILL., E CUTED UNDER THE ORDERS OF THE MISSISSIPPI RIVER COMMISSION, 1880–'81–'

1. *Report of Assistant Engineer J. A. Paige upon the field-work of* 1880–'81, *Grafton to Ca*

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., September 21, 188

SIR: I have the honor to make the following report of field operations on pre levels on the Mississippi River, between the mouth of the Illinois River and Ca from August 10, 1880, to March 16, 1881.

The organization of the party was as follows: James A. Paige, assistant engin in charge; O. W. Ferguson, assistant engineer; E. H. Sankee, recorder; H. P. Bou recorder; four rodmen, one cook, and eight axmen.

On October 23, Mr. Sankee, by your orders, was transferred another party, Mr. P. P. Sanborne reported for duty on the same day.

Your verbal instructions previous to my taking the field, were: To quarter party on the quarter-boat Louisiana, obtain the necessary instruments from

office, purchase subsistence stores, and have the outfit towed to Grafton; establish a bench-mark on the right bank of the Illinois River near its mouth, which should be the beginning of the line; transfer the levels across the Illinois River; carry the work (which would consist of two independent lines of levels) down the left bank of the Mississippi River to the mouth of the Missouri; cross here to the right bank of the Mississippi River, in order that permanent bench-marks might be well established in the edge of the bluffs, which form the right bank mainly from Saint Louis to Commerce; and ultimately connect with the bench-marks in Cairo established by General Comstock's parties in 1876.

On August 10, the quarter-boat was furnished and, by the steamer Little Eagle No. 3, was towed to Grafton. The first field-work consisted of determining the constants of Kern levels Nos. 1 and 2, and the level vials belonging to them. Kern level No. 1 was used by O. W. Ferguson with level vial No. 7 till October 7, when it was broken; after that date level vial No. 3 was used. Kern level No. 2 was used by James A. Paige with level vial No. 2 throughout the season. Redeterminations of the value of the constants were made as follows:

Wire intervals of both levels at Neeley's Landing and at Cairo.

Relative size of rings of level No. 2 at Neeley's Landing and at White Sand Depot Landing.

Value of one division of level vial No. 2 at Neeley's Landing and Cairo.

Value of one division of level vial No. 3 was determined at Illinois station, where it was first used, and again at Neeley's Landing and at Cairo.

In reduction of the field-notes the value of these constants found at any time was used until a new determination was made; after that time the last value found was used.

The weather for the first three months of the field season was very favorable to the work. On the 15th of November cold weather set in, and from that date till February 22 there were only 25¼ days for both parties of field-work done. While at Neeley's Landing December 18, the ice began running so badly that the quarter-boat could be moved no farther. This hindered the work very much. Finally the river was entirely frozen over, and remained so till February 3, when a cake of ice extending entirely across the river struck the quarter-boat and sunk her. With the aid of a derrick and some other appliances obtained at Grand Tower the boat was raised and repaired, and on February 22 moved to Commerce, Mo., to which point Assistant Ferguson had carried the levels.

The work was completed to Cairo on March 14, the quarter-boat towed to Mound City and turned over to watchman Schoenfeld, and with Mr. Ferguson I reported to you for further duty at Saint Louis.

The general conditions regarding the work during the latter part of the season were unfavorable. Low water prevailed nearly the entire season. To move the quarter-boat by drifting with the current very often resulted in being hung up on a rock or blown on a sand bar. The boat lay at Neeley's Landing nine weeks. Part of the force remained to look after the boat, while Assistant Ferguson continued the work below whenever the weather would permit, subsisting at farm houses.

During this time and for some time previous the ground was frozen, and, as has been found previously, when running over such a surface, it is impossible to keep the level stationary. Also, part of the line was through wheat fields and swampy woods. About 22 per cent. of the whole distance was leveled more than twice, and one per cent. was leveled more than three times.

The whole number of days and parts of days spent in field-work equals 220 days for one party. The whole number of kilometers leveled equals 797.5. Average rate per working day equals 3.6 kilometers.

There were 66 permanent bench-marks established. Eleven of these were of the usual pattern—stone posts in ground with copper bolt in top. The remainder, with one exception, were copper bolts one centimeter in diameter and 7 centimeters long, leaded in brick or stone foundations, or in the natural rock wall. Those of the latter locality, if not interfered with, are as permanent as anything of this nature can be established. Where the copper bolts were set horizontally a small hole in the end of the bolt marks the point of reference. Temporary bench-marks were set about once in every kilometer.

While in the field, a descriptive list of bench-marks was received, established in 1879, by surveys made under direction of Colonel Simpson, Corps of Engineers, between Carondelet and Kaskaskia, with directions that they be connected with. Thirty-three of these sixty-four bench-marks were found and connected with. They are designated in the field-notes and office computations as "B. M.—Holman."

There were six water-gauges connected with the levels, viz: at Grafton, Saint Louis, Rush Tower, Grand Eddy, Gray's Point, and Cairo. At all of these gauges except the Gray's Point gauge, there was a permanent bench-mark left in the immediate vicinity.

The methods used in field-work were, with a few exceptions, the same as have been

used heretofore, and need not be further described, any changes made being incider to the locality, state of the weather, &c.

There were 4 river crossings made by reciprocal leveling—one at the beginnin the work across the Illinois River, one at the mouth of the Missouri, one at Ches and one at Commerce. When these crossings were made, a copy of the field-nc and computations was forwarded to you.

Very respectfully, your obedient servant,

JAMES A. PAIGE,
Assistant Enginee

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

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2. *Reports of J. B. Johnson upon the field-work of* 1882-'83, *Carrollton to Biloxi,* *Grafton to Chicago.*

a.—CARROLLTON TO BILOXI.

NEW ORLEANS, LA., *June* 26, 1882

SIR: I have the honor to report upon the field-work of the precise level party der my charge, in connecting the United States bench-marks at Carrollton, La., w the tide-gauge at Biloxi, Miss.

The party consisted of J. B. Johnson, assistant engineer in charge; O. W. Fer son, assistant engineer; A. Ramel, recorder; A. E. Kastl, recorder, together with rodmen and five laborers.

I left Saint Louis May 3, reaching New Orleans on the 5th. A reconnaissance w made on that day, and a line agreed upon for reaching the Mobile and New Orle railroad by running back of the city. On the 6th instrumental constants were served, and on Monday, May 8, the regular work commenced.

On the 9th I left the party for five days, under orders to visit the observation pa at Red River Landing. Recorder Ramel observed with my instrument while I was this trip, as well as on all other occasions when it was necessary for me to be abs from the work. The work was completed at Biloxi tide-gauge June 23. Instr mental constants were observed on the 24th, and the party returned to New Orle on the 26th. A connection was then made with the New Orleans City datum, whi could not be found when the work was in that vicinity.

The party was disbanded June 27. Mr. Ferguson taking part of the outfit to C lumbus, Ky., and the remainder shipped to Saint Louis by Anchor Line steamers.

DESCRIPTION OF THE LINE.

The total length of the line from Carrollton to the Biloxi gauge is 139 kilometers 87 miles. Of this, 18 kilometers was on wagon roads, 50 kilometers on railroad throu swamp, 7 kilometers on railroad bridges and trestles, 64 kilometers on railroad ov dry sandy land.

The characteristics of the swamp region were learned from the road master. says there is a solid sand bottom from 2 to 15 feet below the surface throughout t whole distance. A vegetable growth and mold has formed on the surface, which e tends some 2 or 3 feet down. If the sand substratum is deeper than this, the inte mediate region is filled with a soft liquid mass which offers no resistance whateve The road-bed was first made by dredging a canal alongside the line, and depositir the mud on the line. Sand was then brought in scows, on this side canal and put top of the mud road-bed, until it was stable enough to lay a track.

For several years after the track was laid the road-bed rapidly settled away i places and more sand was constantly hauled to raise it again. Lines of piles we driven in many places between the track and the side canal, to prevent the road-be from flowing back into the canal. These piles are all driven into the solid sand bo tom, however, and are very firm. The road-bed now seems to be quite stable, and think the fill has sunk down to the solid substratum and there will be little mo settling away. All the piling under the bridges and trestles are driven in sand. O lines checked quite as well through the swamp region as on the solid ground. Th road-bed for the entire distance, is composed of sand, which makes an excellent bas

for foot plates and instruments as it is non-elastic. The 7 kilometers on bridges and trestles were distributed as follows:

	Meters.
Chef Menteur-Bridge	560
Rigolets Bridge	1,100
Pearl River Bridge	520
Bay Saint Louis trestle	3,700
Biloxi Bay to gauge trestle	1,120
Total kilometers	7.000

The bridges were double quadrangular iron truss bridges of 100 feet span, resting on piers made up of sixteen piles each. These piles were well capped and held at top. and also by diagonal tie-iron rods, reaching from top to bottom of piers. The trestle-work rested on piers every fifteen feet, of six piles each. The water was not over 20 feet deep on any of these crossings, except that of the Rigolets, which was as much as 48.

The Chef Menteur, Rigolets, and Pearl River are outlets from Lake Pontchartrain into Lake Borgne, and are subject to strong currents as the tide ebbs and flows, or the wind drives the water in or out. All these bridges and trestles were found very solid, and furnished a good basis for the instruments when there was little wind and current, otherwise work could not be done on them. These were all crossed four times under favorable circumstances, except Pearl River bridge, which was crossed but three times. All these lines agreed as closely as on any other part of the work.

METHODS OF WORK.

The methods employed were, in the main, the same as those heretofore used with the Kern instruments and rods. The two lines were always run in opposite directions, Mr. Ferguson always running west, and I always running east.

In one particular the methods of making the observations have differed from those previously used, and that is *the bubble was always kept in the middle of the tube when taking a reading*

This method was not adopted arbitrarily or rashly. In my first season's work I found that my bubble changed its value from 2.6 to 3.5 seconds, according to temperature. I therefore kept my bubble corrections *very small* so as not to introduce any large uncertainty from that source. In the first half of last season I followed the same plan, and with many readings would have no bubble correction at all. In the latter half of that season's work I kept the bubble exactly in the middle for almost all readings, and found it could be done as well as not. This, of course, presumes that the observer reads his own bubble, a thing which I have always done. Last season Mr. Ferguson had his recorder read his bubble and so could not pursue this method.

A discussion of these two systems is important.

(I.) Having the recorder read the bubble has some advantages, *provided the bubble will stand*. He then can wait till it settles, inform the observer of the fact, and he can read the bubble *in its true position while* the observer reads the rod.

The objections to this are:

(*a*.) It is desirable to have as few men about the instrument as possible. If the recorder reads the bubble there are three men, observer, recorder, and umbrella man, standing directly beside the instrument.

(*b*.) I find that my bubble will seldom stand long enough for me to read the three wires; a single bubble reading is, in this case, certainly erroneous.

(II.) The advantages of the other system are, that it enables the observer to make the complete observation, and also to get all three wire readings with the bubble in one position.

To have one man read the bubble and another to take the shot is like having one to sight a gun and another to pull the trigger, a very good plan with a *fixed gun*, but a very poor plan when the gun is somewhat unsteady and controlled by the man who pulls the trigger. When the bubble is almost constantly in motion, the same man must see both bubble and wires, and at the same time, and keep them both in view, in order that he may know when the bubble is registering correctly. By holding the head to one side the observer can keep his left eye on the bubble and his right eye on the rod, and see the bubble super-imposed on the rod; or, if he finds it difficult to read with both eyes at once, he can see bubble and rod alternately without moving his head and only by opening and closing his left eye. Now with his hand at the elevating screw, under the eye end wye, he brings the bubble to the center and keeps it there, stopping to look at the bubble for each wire reading.

After having read one wire, if the bubble has run, bring it back, read the next wire, again examine the bubble, bring it to the center again, and read the third wire.

Let him do the same also for the second set of readings (for the wires should al
read twice), and then, having kept the bubble in the same place, he can confide
assert the reliability of his work. With 100-meter shots, if the bubble is read
half division wrong, an error of $0^{mm}.6$ has been made.

The bubble often seems to have stopped moving when one-half to three-quar
division from its true point of equilibrium, and therefore the second set of wire r
ings will often differ from the first.

It may be said it requires too much time to bring the bubble exactly in the mid
but I think it requires no more time than to bring it to any other point, for it m
be watched and kept to one reading anyway, if good work is to be done, and it m
as well be kept in the middle as anywhere else.

I have run 1½ miles per hour by this method of work, on 100-meter shots, and I
not find it at all difficult to make ten settings an hour of 80-meter shots, makin
mile an hour on 80-meter shots. This got to be about our normal gait.

Another objection that is made to the observer's reading his own bubble, is t
he cannot read it correctly, there being a parallax of about one-half division at e
end, caused by the light passing obliquely from the bubble to the mirror, in orde
reach the eye.

The instructions say that the eye must be held in such a position that there wil
no parallax. This cannot be done. The objection, however, has little force, provi
the back and fore sights are kept equal. The error being always constant and eff
ing back and fore sights alike, their difference is not changed, and if the back
fore sights are very unequal, this one-half division error in bubble reading can be
plied, together with the corrections for collimation, inclination, and pivots. In t
it and the pivot error being sensibly constant, may be combined, and their resul
used in connection with collimation and inclination errors. For these reasons I
termined on having no bubble corrections in my work for this season, and Mr. Fe
son, with some reluctance, adopted the same method. I think our extraordinary c
agreements amply justifies the scheme.

I believe that, when the conditions are favorable, this matter of the bubble re
ings is the chief source of error. If the saving of time in the computations may
allowed as an argument, this method has a great advantage over the old one.

Our field work has all been reduced in two note-books, instead of on the compu
tion sheets, with a saving of three-quarters of the time it formerly required for
work. This certainly reduces the cost of the field work, for that now never has t
stopped to work up notes. I therefore conclude that the method is more accur
less laborious, and cheaper than that formerly used. The value of the bubble a
and the changes in the same, become of no consequence, neither is an accurate va
of the wire interval of much account, except as getting the distance run.

In all other respects the methods employed have been the same as those used bef
The permanent bench-mark stones have generally been set on side lines, so that
settling that may have occurred in them has not affected the accuracy of the line

Twenty-two permanent bench-marks have been set, twelve of which are stones
in the ground, east of Pearl River, and the rest are copper bolts leaded into dr
piers, abutments, brick buildings, &c. Superintendent J. T. Harahan very kin
gave us the use of a hand-car, which was of great service and materially facilita
the work. No other favors were asked or received from the railroad company,
in return for this one, I have prepared a list of our permanent bench-marks with th
elevations, and also the elevations of the road-bed at every station, which will am
repay them for the use of the car.

Most of the work has been done from 6 to 8 a. m. and from 4 to 7 p. m. There h
been very few days when work could be done between 8 a. m. and 4 p. m.

The party were quartered at but six places between New Orleans and Biloxi, a d
tance of 80 miles, three of these being club-houses for New Orleans hunters and fi
ermen.

RESULTS.

The length of line was 139 kilometers (87 miles). This was run in forty-sev
days, May 8 to June 23, inclusive. Seven kilometers of this distance (4.4 miles) w
required to be run four times. This gives 91.4 miles of duplicate line completed
forty-seven days, 1.9 miles per day. The full party was under pay fifty-one da
Field-work was done on thirty-six days, making an average of 2.6 miles per day
every day on which work was done. Of the remaining fifteen days nine were Sunda
four were rainy, one was windy, with the tents inaccessible, and one day was spent
connecting with a stone and setting a water-gauge at "West End" on Lake Pontch
train.

DISCUSSION OF RESULTS.

There were five discrepancies in the season's work beyond the limits; four of th
were errors of 10 millimeters, and one of 20 millimeters. It is pretty well determin
that these all occurred by allowing the rods to get out of the sockets in the foot-plat

These sockets are just 10 millimeters in depth; every time a train passes the rod is taken out, and in replacing it the rodman is very careful not to jar the plate. Neither should he incline the rod too much in putting it back for fear of bringing a lateral pressure on the plate and so moving it. He therefore cannot get down to look at it, neither can he let it in so as to hear the click as it drops into the socket, as he can when he first sets up, so that some of those errors may have come in from this cause.

Another cause would be the strong wind, in which we were often able to work on account of the protection afforded the instruments by the tents. The rods, however, had no protection, and it was with the greatest difficulty that the rodmen managed to keep their rods in place. They used a stick to brace up the rod on the leeward side, and if this was held firmly against the rod, the wind against the top, would tend to lift the rod bodily out of the socket. One of the rods was found in this condition one day, the spur resting out on the top of the plate, and it had evidently been done in this way, the rodman not being conscious of the change.

Aside from these five errors, which determinations were rejected in the field computation, there were no discrepancies beyond the limit on the entire line.

A number of stretches were run a third and fourth time to reduce the probable error, although already within the limit, all determinations being used.

There was no marked divergence in the plot of the two lines until the last two weeks. This, I think, was caused by the road-bed becoming very dry, there having been no rain in that time. When trains pass, the whole road-bed is shaken somewhat, and if there is dry sand about the foot-plates it is liable to work under them, and so raise them slightly. The discrepancies are in the direction to indicate a raising of the foot-plates. The results obtained on the bridges and trestles are very satisfactory.

We have for the five such stretches:

Locality.	Distance.	Number of lines.	Maximum discrepancy.	Probable error of mean.
	m.		*mm.*	*mm.*
Chef Menteur	560	4	1.3	0.2
Rigolets	1,100	4	1.3	0.2
Pearl River	520	3	0.9	0.2
Bay Saint Louis	3,700	4	3.5	0.5
Biloxi Bridge	1,120	4	3.5	0.5

Many trains passed, both while crossing these bridges and also between the different crossings. The evidence is conclusive that there is no appreciable settling of these piles for passing trains. The probable error in the mean for the entire line is 7 millimeters. This corresponds to a probable error in the mean of 0.60 millimeters per kilometer, a degree of accuracy not hitherto attained, I believe, in this country.

It will be seen, by comparing their elevations in the summary, that the 6-foot mark on the Biloxi gauge is 25 5 millimeters below the zero of the Carrollton gauge. The keeper thinks mean tide is a little below the 6-foot mark. It is likely, therefore, that the zero of the Carrollton gauge will prove to be some 2 or 3 inches above mean tide.

The work is much indebted to the attention paid to it by Major Harrod. It was through his influence that a hand-car was obtained, and also that the party was allowed to occupy various club-houses through the swamp region. The organization of the party was very satisfactory. Mr. Ferguson is always to be commended for the intelligence, care, and conscientious devotion he brings to the work, and Recorders Ramel and Kastl are well deserving of further employment. Mr. Ramel acted as an observer on 31 stretches, aggregating 24 miles, on only one of which was the discrepancy beyond the limit, and that one by 10 millimeters, probably an error of the rodman

Very respectfully, your obedient servant,

J. B. JOHNSON,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Corps of Engineers, U. S. A., Secretary Mississippi River Commission.

b.—GRAFTON TO CHICAGO.

SAINT LOUIS, *September* 1, 1883.

SIR: I have the honor to submit the following report of the field work of precise levels from Grafton to Chicago. This work was done in three seasons, viz:

I. Grafton to Keokuk, 151 miles, done May 21 to August 30, 1881.
II. Keokuk to Fulton, 170 miles, done September 6 to November 25, 1882.
III. Fulton to Chicago, 170 miles, done May 2 to August 7, 1883.

The observers for all this work were O. W. Ferguson and J. B. Johnson. Each (server had a recorder, two rodmen, and two axmen at his disposal, thus making t separate working field parties. Both parties were quartered together, and were charge of J. B. Johnson. From Grafton to Keokuk they lived on a quarter-boat; fr Keokuk to Chicago they found accommodations in the villages, and used a hand-(to go to and from work. Of the 491 miles of line from Grafton to Chicago, 406 mi were run on railroads, and 85 miles along the edge of the river bank. From Grafton Savanna, the most northerly point reached on the river, railroads were only used wh they were in close proximity to the river bank.

BENCH-MARKS.

From Grafton to Chicago 147 permanent bench-marks were set, 110 of which m be found near to the river, between Grafton and Savanna; of the remaining 37, are on the line of the Chicago, Milwaukee and Saint Paul Railway, from Savanna Chicago, and 6 in the city of Chicago. These bench-marks are nearly all copper bo leaded into natural rock, bridge piers, and abutments, foundations of buildings, a in stones set in the ground. They are generally marked with the letters U S ⊙ P B arranged in this manner about the bolt-head. Most of them are set horizontally vertical walls and faces of rock, and the balance vertically in horizontal surfac The latter are more convenient to connect with, but are more liable to be disturb and covered from sight.

In addition to these permanent benches, connection was made with 30 "permane bench-marks" set in Colonel Farquhar's survey of the Mississippi River, and pu lished in the Report of Chief of Engineers for 1880, page 1520.

Temporary bench-marks were set about every kilometer, or whenever the work w interrupted. There were usually points of natural rock, abutments, spikes in stum or roots of trees, or in the trestle-work over piles, or else stakes driven in the groun Where the stability of the temporary bench was not assured, more than one was se in this case, both were connected with again in starting from them, and the me elevation of the two was used in continuing the line. With but one exception, temporary bench was ever found to have moved, and this one was a spike in a cattl guard where the timbers were afterwards found to be decayed. This movement w discovered in the field, and the line continued from the next set of benches back the line.

LOCATION OF LINE.

The location of the line run is as follows:

From Grafton to Clarksville, 58 miles, on the east bank of the river.

From Clarksville to Burlington, 135 miles, on the line of Saint Louis and Keokul and Chicago, Burlington and Quincy railways, on the west bank.

From Burlington to New Boston, 36 miles, on the line of the Chicago, Burlington an Quincy Railway, on the east bank.

From New Boston to Port Louisa, 9 miles, on the east bank, through the bottom

From Port Louisa to Muscatine, 18 miles, on the west bank, through the bottom

From Muscatine to Rock Island, 29 miles, on the line of the Chicago, Rock Islan and Pacific Railway, on the west bank.

From Rock Island to Savanna, 58 miles, on the line of the Chicago, Milwaukee an Saint Paul Railway, on the east bank.

From Savanna to Chicago, 148 miles, on the line of the Chicago, Milwaukee an Saint Paul Railway.

This necessitated crossing the river four times with the line of levels, viz, a Clarksville, Burlington, Port Louisa, and Rock Island.

At Clarksville and Port Louisa the crossings were effected by simultaneous reading with two instruments on opposite sides of the river, the midwire bisecting a larg target on the opposite shore. Sixteen readings were taken by each instrument, i sets of four, which were as follows:

1. Telescope normal, level direct.
2. Telescope normal, level reversed.
3. Telescope inverted, level direct.
4. Telescope inverted, level reversed.

Then each observer, with his instrument, crossed over, and the same was repeated

The longest readings thus taken were about 600 meters. Very good results wer obtained, the probable error being less than a millimeter.

At Burlington and Rock Island the crossings were made on bridges.

INSTRUMENTS.

The instruments used on this work are the Kern levels, and rods similar to those used in the precise levels of Switzerland, and are made by J. Kern, of Aarau. The instrument, with tripod, weighs 22 pounds. It has three steel leveling screws, with enlarged spherical ends at bottom, which are held to the tripod head by clamps fitting over the spherical enlargements. The wye adjustment is by means of a thumb-screw of very fine thread, so that the last final centering of the bubble is made with this screw. The bubble tube is fixed in a striding wooden case, with brass ends fitting on the collars of the telescope. The bubble case has a glass cover and a mirror that may be raised to the angle of 45° and so reflect the bubble image to the eye of the observer at the eye-piece. The telescope clamps also hold the bubble case in position; this is removed, however, when the instrument is carried. The telescope gives an inverted image. The reticule has three horizontal wires, all of which are read, and the mean taken as the reading of that sight. This also gives a stadia measurement of the distance.

The rods are 3 meters long, made of two pine boards with a T-shaped cross section, provided with an iron spur at bottom with a flat end, and a watch level by which to hold it vertical. They are graduated to centimeters, and are read by estimation to millimeters. No target is used.

FIELD METHODS.

1. *Duplication.*—In all this work the lines between benches have always been duplicated by running the second line in the opposite direction. From Grafton to Keokuk the duplicate lines were run by different observers, Mr. Ferguson always running north and Mr. Johnson south. From Keokuk to Chicago each observer duplicated his own work. It was never attempted to carry two lines simultaneously with one instrument.

2. *Observation.*—Great care was taken to always get the back and fore sights equal in length. Since the interval between extreme wire readings gave a stadia measurement of the distance, the recorder knew, by means of the continued sum of back and fore sight intervals, at all times, what the total difference was, and could instruct the rodman to make the requisite correction. This was carefully attended to.

The bubble was always read by the observer in the mirror set for that purpose. This was read by the observer's left eye, without removing his right eye from the eye piece. There was a small parallax on the bubble when the eye was in this position, but since the error was constant for both back and fore sights, it was eliminated. From Grafton to Keokuk the bubble was brought approximately to the middle and read, and a correction applied for its eccentric position. From Keokuk to Chicago, the bubble was brought carefully to the center and held there by means of the very delicate wye adjusting screw, so that there were no corrections for bubble displacement on this part of the work. The latter method was found to be about as convenient in the field, and it saves much work in reduction.

In connecting with horizontal benches it was the common practice to set the instrument on a plane with the bench and make the middle wire bisect the small hole in the center of the bolt, reading both back sight on rod and fore sight on bolt, with the telescope in both normal and inverted positions. This was necessary, because three wires were read on the rod, and the middle wire did not exactly coincide with the mean of the three.

The rod supports used in 1881 and 1883 were iron foot-plates of some 18 square inches area, triangular in shape, having a handle, 3 spurs at bottom, and a socket in the top, with a convex bottom to receive the spur of the rod. In 1882 iron pins were used in addition to the foot-plates, or, in place of them, on portions of the line where, from our experience, they were thought to be better than the plates. This was on alluvial, moist, or springy ground, where the plates were liable to change their elevation. Sometimes in the woods it would be almost impossible to get good solid earth on which to set the plate. The pins were found to work very well in these places, but in loose earth, as sand or unpacked gravel, the foot-plates are greatly superior. If but one kind of support is to be used under all conditions, the foot-plates are preferable.

INSTRUMENTAL CONSTANTS AND ADJUSTMENTS.

The value of one division of the level bubble in seconds of arc was determined two or three times each field season, also the difference in the diameters of the telescope collars, and the correction therefor, and the value of the wire intervals. The adjustment of the bubble tube, and the line of collimation of the mean of the three wires, to the axis of the telescope collars, was made or examined every time the instruments were set up, and again on closing a stretch. In the former case the error of paral-

lelism was made very small, and in the latter its absolute value, in seconds of a was found by reversed readings. These values, found at the close of the stret called corrections for "inclination" and "collimation," together with the correct for inequality of collars, called the "pivot" correction, were all evaluated for the sidual difference in distance between sums of back and fore sights, and the result correction applied to the computed elevation of the forward benches. The algebr sums of these corrections seldom amounted to more than one or two-tenths of a mi meter, on account of the care taken to keep the back and fore sights equal.

The corrections resulting from the condition of the instrument at the close of stretch were alone used, because where constant care had been exercised to keep back and fore sights balanced up, the residual difference would usually be made the last one or two settings.

PROGRESS.

The following table shows the rates of progress made in the three seasons:

Item.	Grafton to Keokuk.	Keokuk to Fulton.	Fulton to Chicago.	Grafton Chicag
Length of line	151	170	170	
Number of days in entire field season	94	81	98	
Number of days in which work was done	73	58	67	
Average daily run in miles for entire season	1.6	2.1	1.7	
Average daily run in miles for working days	2.1	2.9	2.5	

These average runs may be taken as finished duplicate work by the two parties as single line by one party.

The greater progress made in the season of 1882 was due to the good weather a the use of the hand-car and the observing tents. These latter were made to be u on the Gulf coast to protect the instrument from the wind. They are 5 by 6 feet wa tents, with one 8-foot center pole, held at bottom by eight steel pins. They allow work to be done on many days when it would have been impossible without them

CONNECTIONS AT CHICAGO.

The object of carrying the line to Chicago was to connect with Lake Michig The Lake Survey had determined the elevation of certain bench-marks at Milwauk as well as the mean elevation of Lake Michigan, for the months of May, June, Ju and August, 1875, and also the mean elevation of the lake from January 1, 1860, December 31, 1875, above mean sea-level at New York City.

At Chicago a gauge had been read three times a day at the crib, being the entra to the tunnel two miles from shore, since 1872. This gauge had apparently remain undisturbed since it was first set. Its zero was set at 8.01 feet above city direct by spirit levels carried through the tunnel. In 1878 a water-level connection of gr accuracy was made by the present city engineer, Mr. S. G. Artingstall, between t crib and the shore, and the crib gauge was found to be 0.246 foot too low by the sh benches. The crib gauge was taken as correct, however, and corrections applied the shore bench-marks. By this decision the city directrix is a point 8.01 feet bel the zero of the crib gauge.

The line of precise levels was joined with eight city benches and with the c gauge by water levels. These water levels consisted in reading 3 gauges on shore a 2 at the crib every five minutes for seven consecutive hours on a calm day. This co nection from shore to crib agreed with that of the city engineer in 1878 to the near thousandth of a foot.

Having thus joined the line of precise levels with the zero of the crib gauge, it mained only to obtain a comparison of gauge-readings at Chicago and Milwaukee transfer the Milwaukee elevations to Chicago. Thus the Mississippi River line precise levels is joined to the United States Lake Survey line of levels from New Yo City. (For a description of the determination of the elevation of the Great Lak see Professional Papers, Corps of Engineers, No. 24, p. 595.)

The following recorders have assisted on the work: A. Ramel, P. P. Sanborn, L. Aruer, E. K. Woodward, jr., and S. J. Fitzhugh, all of whom discharged th duties with credit. My assistant, Mr. O. W. Ferguson, deserves especial mention f the accuracy and rapidity with which he has always done his work.

Very respectfully, your obedient servant,

J. B. JOHNSON,
United States Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

3. *Report on reduction of precise levels, by L. L. Wheeler, assistant engineer.*

COTTONWOOD POINT, MO.,
October 29, 1883.

SIR: I have the honor to submit the following report upon the reduction of precise levels, made under my direction. These levels include the following sections: From Carrollton, La., to Biloxi, Miss., a distance of 140 kilometers; from Grafton, Ill., to Cairo, Ill., a distance of 346 kilometers; from Keokuk, Iowa, to Grafton, Ill., a distance of 242 kilometers; and from Keokuk, Iowa, to Fulton, Ill., a distance of 267 kilometers.

In the reductions made under my direction, the greatest care has been taken that no errors of computation should enter into the results. All reductions have been checked, either by comparison with the corrected field reduction, or by two persons computing the same results independently. It is therefore believed that the results here given may safely be taken as the correct ones resulting from the observations.

In these four sections the instruments used were alike, and the method of field work nearly the same throughout.

The instruments and rods were manufactured by J. Kern, of Aarau, Switzerland, and are similar to those described in the Report of the Chief of Engineers for 1877, page 1190.

Table A shows the various determinations of the instrumental constants up to the date of the completion of the line from Keokuk to Fulton.

Table B shows the instrumental constants used in reducing the notes of each section, and the computers' names. In this table i and i' are the angular distances of the upper and lower wires, respectively, from the midwire, and I is the angular distance between extreme wires. The remainder of the table is sufficiently explained by the headings of the columns.

TABLE A.—*Constants for Kern levels and Kern level rods.*

[p is for "pivot correction," or correction for inequality of telescope rings. It is the angular correction to be applied to the line of collimation to reduce it to the horizontal plane of the upper surface of the rings. v is the value of one division of the level tube in seconds of arc. L is the length of a three-meter rod.]

Number of instrument.	Constant.	Date.	No. of observations.	Probable error.	Remarks.
	″			″	
Kern level.............1	$p = -0.34$	Aug. 14, 1880	42	± 0.30	
1	$p = -1.04$	May 24, 1881	10	± 0.18	
1	$p = -1.50$	Aug. 11, 1881	10	± 0.05	
1	$p = -2.66$	Aug. 27, 1881	10	± 0.06	
1	$p = -1.38$	Feb. 3, 1882	7	± 0.09	
1	$p = -3.52$	May 11, 1882	14	....	
1	$p = -1.91$	June 24, 1882	10	± 0.06	
1	$p = -2.46$	Dec. 20, 1882	8	± 0.13	
2	$p = +0.99$	Aug. 16, 1880	4	± 0.03	
2	$p = +0.50$	Oct. 22, 1880	8	± 0.07	
2	$p = +1.84$	Jan. 8, 1881	16	± 0.02	
3	$p = +2.53$	May 26, 1881	8	± 0.03	
3	$p = +0.17$	Feb. 4, 1882	5	± 0.11	
3	$p = +0.19$	May 11, 1882	14	....	
3	$p = +1.10$	June 24, 1882	10	± 0.06	
3	$p = +2.71$	Sept. 6, 1882	6	....	
3	$p = -0.37$	Dec. 21, 1882	8	± 0.10	
5	$p = -1.85$	Feb. 4, 1882	5	± 0.05	
Kern level tube........2	$v =$ 4.08	Aug. 14, 1880	74	....	
2	$v =$ 3.83	Aug. 16, 1880	33	....	
2	$v =$ 4.49	Aug. 19, 1880	37	....	
2	$v =$ 5.60	Jan. 8, 1881	23	....	
2	$v =$ 4.61	Mar. 15, 1881	34	....	
3	$v =$ 3.06	Oct. 7, 1880	24	....	
3	$v =$ 3.25	Oct. 9, 1880	28	....	
3	$v =$ 3.27	Jan. 7, 1881	32	....	
3	$v =$ 3.22	Oct. 14, 1881	30	....	
3	$v =$ 2.90	May 24, 1881	10	± 0.04	
3	$v =$ 3.24	Aug. 9, 1881	10	± 0.02	
3	$v =$ 3.04	Aug. 27, 1881	10	± 0.03	
3	$v =$ 3.21	May 6, 1882	6	....	
3	$v =$ 3.19	June 23, 1882	12	....	
5	$v =$ 2.94	May 25, 1881	6	± 0.02	
5	$v =$ 2.85	Aug. 9, 1881	36	± 0.01	
5	$v =$ 2.76	Aug. 27, 1881	10	± 0.03	
5	$v =$ 2.86	May 7, 1882	6	....	
7	$v =$ 4.25	Aug. 13, 1880	80	....	
11	$v =$ 2.66	Aug. 21, 1880	19	....	

[illegible]—Continued.

[illegible]—Continued.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			J.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			J.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
[illegible] and [illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			J.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			R.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			R.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
*[illegible]	[illegible]	E	[illegible]			[illegible]	[illegible]	0.0	[illegible]	J.
T. B. M. [illegible] and [illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			R.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
T. B. M. [illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]		[illegible]			J.
		W	[illegible]	[illegible]						F.
		Mean	[illegible]							
T. B. M. [illegible]	82.17	E	[illegible]	[illegible]	0.9		[illegible]			J.
		W	[illegible]	[illegible]						F.
		E	[illegible]	[illegible]						J.
		W	[illegible]	—0.4						F.
		Mean	—0.6745							
T. B. M. 61 and 61a.	84.68	E	+2.3275	—0.1	0.3		11.3315			J.
		W	+2.3265	(†)						F.
		E	+2.3267	+0.7						J.
		W	+2.3280	—0.6						F.
		Mean	+2.3274							
*U. S. P. B. M. 9	85.80	E	—0.2700	—1.0	0.6	6.4	11.0605	+0.1	11.0606	J.
		W	—0.2719	+0.9						F.
		Mean	—0.2710							
T. B. M. 62	85.43	E	+0.2808	—0.2	0.1		11.6121			J.
		W	+0.2804	+0.2						F.
		Mean	+0.2806							
T. B. M. 63	86.45	E	+0.1237	+0.1	0.1		11.7359			J.
		W	+0.1240	—0.2						F.
		Mean	+0.1238							
T. B. M. 64	88.28	E	+0.8683	+3.3	1.		12.6075			J.
		W	+0.8744	—2.8						F.
		E	+0.8721	—0.5						J.
		Mean	+0.8716							

† Rejected.

TABLE B.

	Number of instrument.	Constants of instruments. p	i	i'	I	Bubble tube.	v	Rods.	Mean value of one meter.	Computers.	Remarks.
		"	′ "	′ "	′ "		"		m.		
Carrollton to Biloxi....	Kern level 1	−2.72	17 24.21	17 27 04	34 51.25	No. 3..	3.20	X XII XIV XV	1.000048	L. L. Wheeler........	New lower horizontal wire put in No. 3 June 1, 1882.
	Kern level 3	+0.64	17 13.90	17 23.95	34 37.85	No. 5..	2.86		....	Alex. E. Kastl	
	Kern level 3	....	17 18.74	17 24.10	34 42.84	....	......	....			
Grafton to Cairo.......	Kern level 1	−0.34	17 23.90	17 24.31	34 48.21	No. 2..	4.50	X XI XII XIII	1.000009	L. L. Wheeler.........	New vertical wire put in No. 3 August 20, 1880.
	Kern level 2	+1.35	17 31.73	17 20.56	35 01.29	No. 3..	3.21		....	O. H. Ferguson	
	Kern level 2	....	17 31.32	17 30.50	35 01.82	No. 7..	4.25	....	....	Alex. E. Kastl	
Keokuk to Grafton	Kern level 1	−1.73	17 23.86	17 20.60	34 44.46	No. 3..	3.06	X XII XIV XV	1.000010	J. B. Johnson	
	Kern level 3	+1.35	17 15.10	17 23.69	34 38.79	No. 5..	2.85		....	O. W. Ferguson	
	Kern level 5	−1.85	17 42.98	17 28.64	35 11.62	....	......	....	....	Alex. E. Kastl	
Fulton to Keokuk	Kern level 1	−2.46	14 15.99	14 02.38	28 18.37	No. 3..	3.20	XIV XV XVI XVII	1.000029	L. L. Wheeler .... L. L. Wheeler.........	New wires put in No. 3 August, 1882.
	Kern level 3	+1.17	17 13.90	17 23.95	34 37.85	No. 5..	2.86		....	Alex. E. Karal	
										T. C. Thomas	

Accompanying this report are tables of results and descriptions of the perma bench-marks.

In the tables of results column 1 gives the bench-mark, T. B. M., signifying te rary bench-mark, and U. S. P. B. M., signifying United States permanent bench-n

Column 2 contains the distances in kilometers from the initial bench-mark.

Column 3 gives the direction in which the line was leveled.

Column 4 gives the successive differences of elevation in meters between be marks, and the mean of such determinations.

Column 5 gives the residuals found by subtracting each determination from mean.

Column 6 gives the probable error, r, of the mean in column 4, computed by formula

$$r = \pm 0.6745 \sqrt{\frac{[vv]}{m(m-1)}}$$

Column 7 gives the probable error R, of the mean elevation of each perma bench-mark as computed from the beginning of the section.

Column 8 gives the elevations of all bench-marks referred to the Cairo da plane, which is 290.84 feet below the zero of the United States Engineers' gau Cairo, Ill.

Column 9 gives the corrections which are to be applied to the elevations in col 8 to reduce them to standard meters.

Column 10 gives the corrected elevations referred to the same datum plane.

Column 11 gives the initial of the observer for each determination.

"J" is for Assistant J. B. Johnson.
"F" is for Assistant O. W. Ferguson.
"P" is for Assistant J. A. Paige.
"S" is for Recorder E. H. Sankee.
"B" is for Recorder H. P. Bourne.
"Sn" is for Recorder P. P. Sanborn.
"R" is for Recorder A. Ramel.

Column 12 indicates the nature of the support.

The above report is respectfully submitted.

L. L. WHEELER,
Assistant Engine

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Results of precise leveling.

CARROLLTON, LA., TO BILOXI, MISS.

[Bench-marks marked with an asterisk are not in main line of levels.]

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*
C. and G. S. 1, Carrollton.									†9.0272
*B. M. Hampson. (Re-established by Maj. Howell)			−0.3732	+1.1	0.7		8.6551		
			−0.3710	−1.1					
		Mean..	−0.3721						
*B. M. Hampson (Williams).			−0.1980				8.8292		
*B. M. 3, Ripley...			+0.7479	+0.1	0.1		9.7752		
			+0.7483	−0.3					
			+0.7477	+0.3					
		Mean..	+0.7480						

†P. B. M. 1, Carrollton, below P. B. M. 1, Greenville −37.0619 M, furnished in manuscript by the U States Coast and Geodetic Survey. Office Report, 641, A. C. P. B. M. 1, Greenville above datum 46.0891 M. Report for 1882, page 74.

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*B. M. 4, Ripley			+0.4899	+1.0	0.4		9.5181			F.
			+0.4910	—0.1						F.
			+0.4917	—0.8						J.
		Mean	+0.4909							
*B. M. 5, Burney			+0.0032	—0.1	0.1		9.0303			F.
			+0.0030	+0.1						J.
		Mean	+0.0031							
*14-foot mark of water gauge, Carrollton.			+1.6128	+0.2	0.1		10.6402			F.
			+1.6132	—0.2						J.
		Mean	+1.6130							
*U. S. P. B. M. "Carrollton."			+0.1206				9.1478	0.0	9.1478	J.
*City B. M. marked [XX M. B., June. 1874].			—1.2617				7.7655			J.
T. B. M. 1	1.03	E	—1.6586	+1.2	0.8		7.3698			J.
		E	—1.6565	+1.1						J.
		W	—1.6538	—3.6						F.
		W	—1.6585	+1.1						F.
		Mean	—1.6574							
T. B. M. 2	2.38	E	+0.1150	—0.8	0.5		7.4840			J.
		W	+0.1135	+0.7						F.
		Mean	+0.1142							
U. S. P. B. M. 1	3.99	E	—0.5437	0.0	0.0	0.9	6.9403	—0.1	6.9402	J.
		W	—0.5437	0.0						F.
		W	—0.5436	—0.1						F.
		Mean	—0.5437							
*City stone at intersection Washington and Carrollton avenues.	3.66		+0.2793				7.7633			J.
T. B. M. 3	5.02	E	—0.4647	+1.8	1.2		6.4774			J.
		W	—0.4611	—1.8						F.
		Mean	—0.4629							
*City stone, "Half-way House.	6.65		+1.5096				7.9870			J.
*6.5-foot mark of gauge at West End, N. O.	11.48		—0.3475				7.6395			F.
*B. M. "Height of Metairie Ridge."	11.74		+0.0359	—0.1	0.0		7.6753			F.
			+0.0358	0.0						F.
		Mean	+0.0358							
T. B. M. 4	5.66	E	+0.0259	+1.9	1.3		6.5052			J.
		W	+0.0298	—2.0						F.
		Mean	+0.0278							
T. B. M. 5	6.74	E	+0.7989	—0.2	0.1		7.3039			R.
		W	+0.7985	+0.2						F.
		Mean	+0.7987							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.
*U. S. P. B. M. 2	6.76	E	+1.8556	−0.2	0.1	2.0	9.1593	0.0	9.1593
		W	+1.8552	+0.2					
		Mean	+1.8554						
*City stone in city park.	8.14	E	−1.3546	+0.8	0.5		7.8055		
		W	−1.3530	−0.8					
		Mean	−1.3538						
U. S. P. B. M. 3	8.30	E	+0.3701	+0.7	0.5	2.1	7.6747	−0.1	7.6746
		W	+0.3716	−0.8					
		Mean	+0.3708						
T. B. M. 7	9.27	E	+0.1151	−0.9	0.6		7.7889		
		W	+0.1133	+0.9					
		Mean	+0.1142						
T. B. M. 8	9.63	E	−0.2090	+1.4	0.9		7.5813		
		W	−0.2063	−1.3					
		Mean	−0.2076						
T. B. M. 9	11.36	E	+0.2124	+1.6	1.1		7.7953		
		W	+0.2156	−1.6					
		Mean	+0.2140						
T. B. M. 10	12.57	E	−0.7277	+0.7	0.4		7.0683		
		W	−0.7264	−0.6					
		Mean	−0.7270						
T. B. M. 12	13.88	E	+0.4251	+1.9	1.2		7.4953		
		W	+0.4288	−1.8					
		Mean	+0.4270						
T. B. M. 13	14.86	E	+0.0094	−1.2	0.8		7.5035		
		W	+0.0069	+1.3					
		Mean	+0.0082						
T. B. M. 14	16.20	E	+0.1884	−0.8	0.6		7.6911		
		W	+0.1867	+0.9					
		Mean	+0.1876						
T. B. M. 15	18.55	E	−0.5257	+0.4	0.3		7.1658		
		W	−0.5249	−0.4					
		Mean	−0.5253						
T. B. M. 16	19.29	E	−0.0533	+0.1	0.1		7.1126		
		W	−0.0530	−0.2					
		Mean	−0.0532						
T. B. M. 17	20.26	E	+0.5513	+0.9	0.6		7.6648		
		W	+0.5530	−0.8					
		Mean	+0.5522						
T. B. M. 18	20.90	E	−0.3580	+0.4	0.2		7.3072		
		W	−0.3573	−0.3					
		Mean	−0.3576						

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 19	21.79	E	+0.1854	+0.4	0.2	......	7.4930	......	....	J.
		W	+0.1861	−0.3	......	......	....	......	....	F.
		Mean	+0.1858							
T. B. M. 20 and 20*a*	22.78	E	−0.2992	0.0	0.0	......	7.1938	......	....	J.
		W	−0.2993	+0.1	......	......	....	......	....	F.
		Mean	−0.2992							
T. B. M. 21	23.73	E	+0.0510	+0.6	0.4	......	7.2454	......	....	J.
		W	+0.0523	−0.7	......	......	....	......	....	F.
		Mean	+0.0516							
T. B. M. 22 and 22*a*	25.04	E	+0.3924	+0.7	0.5	......	7.6385	......	....	J.
		W	+0.3938	−0.7	......	......	....	......	....	F.
		Mean	+0.3931							
T. B. M. 23	26.76	E	+0.0898	−1.3	0.9	......	7.7270	......	....	J.
		W	+0.0872	+1.3	......	......	....	......	....	F.
		Mean	+0.0885							
T. B. M. 24 and 24*a*	28.29	E	−0.0978	−3.0	1.0	......	7.6262	......	....	J.
		W	−0.1050	+4.2	......	......	....	......	....	F.
		E	−0.1009	+0.1	......	......	....	......	....	J.
		W	−0.0997	−1.1	......	......	....	......	....	F.
		Mean	−0.1008							
T. B. M. 25 and 25*a*	29.92	E	−0.2830	+1.0	0.7	......	7.3442	......	....	J.
		W	−0.2810	−1.0	......	......	....	......	....	F.
		Mean	−0.2820							
T. B. M. 26	31.51	E	+0.3119	+1.9	1.3	......	7.6580	......	....	J.
		W	+0.3158	−2.0	......	......	....	......	....	F.
		Mean	=0.3138							
T. B. M. 27	33.08	E	−0.2046	−1.5	1.0	......	7.4519	......	....	J.
		W	−0.2076	+1.5	......	......	....	......	....	F.
		Mean	−0.2061							
T. B. M. 29 and 29*a*.	36.42	E	+0.0807	+3.4	2.4	......	7.5360	......	....	J.
		W	+0.0912	−7.1	......	......	....	......	....	F.
		W	+0.0804	+3.7	......	......	....	......	....	F.
		Mean	+0.0841							
T. B. M. 30 and 30*a*.	37.25	E	+0.5914	−0.4	0.3	......	8.1270	......	....	J.
		W	+0.5905	+0.5	......	......	....	......	....	F.
		Mean	+0.5910							
T. B. M. 31 and 31*a*	37.82	E	+0.2347	−0.7	0.2	......	8.3610	......	....	J.
		W	+0.2336	+0.4	......	......	....	......	....	F.
		E	+0.2333	+0.7	......	......	....	......	....	J.
		W	+0.2342	−0.2	......	......	....	......	....	F.
		Mean	+0.2340							
*U. S. P. B. M. 4	38.10	E	+0.4191	−3.4	1.3	4.8	8.5427	0.0	8.5427	J.
		W	+0.4173	−1.6	......	......	....	......	....	F.
		W	+0.4101	+5.6	......	......	....	......	....	J.
		E	+0.4164	−0.7	......	......	....	......	....	J.
		Mean	+0.4157							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*
T. B. M. 32 and 32*a*.	39. 67	E	−0. 7311	−1. 7	1. 1	......	7. 6282	......	....
		W	−0. 7345	+1. 7	......	......	....	......	....
		Mean ..	−0. 7328						
T. B. M. 32½	41. 24	E	+0. 0944	+1. 6	1. 1	......	7. 7242	......	....
		W	+0. 0994	−3. 4	......	......	....	......	....
		E	+0. 0942	+1. 8	......	......	....	......	....
		Mean ..	+0. 0960						
T. B. M. 33 and 33*a*.	42. 32	E	+0. 2304	+0. 8	0. 5	......	7. 9554	......	....
		W	+0. 2319	−0. 7	......	......	....	......	....
		Mean ..	+0. 2312						
T. B. M. 34 and 34*a*.	44. 62	E	−0. 5324	−2. 4	1. 6	......	7. 4206	......	....
		W	−0. 5372	+2. 4	......	......	....	......	....
		Mean ..	−0. 5348						
T. B. M. 35	46. 81	E	+0. 8463	−1. 1	0. 8	......	8. 2658	......	....
		W	+0. 8440	+1. 2	......	......	....	......	....
		Mean ..	+0. 8452						
T. B. M. 36	49. 51	E	−0. 0975	+0. 5	0. 4	......	8. 1688	......	....
		W	−0. 0964	−0. 6	......	......	....	......	....
		Mean ..	−0. 0970						
T. B. M. 37 and 37*a*.	51. 65	E	−0. 8964	−1. 4	0. 9	......	7. 2710	......	....
		W	−0. 8991	+1. 3	......	......	....	......	....
		Mean ..	−0. 8978						
T. B. M. 37½	52. 70	E	+0. 0117	+1. 0	0. 5	......	7. 2837	......	....
		W	+0. 0140	−1. 3	......	......	....	......	....
		E	+0. 0123	+0. 4	......	......	....	......	....
		Mean ..	+0. 0127						
T. B. M. 38 and 38*a*.	53. 62	E	−0. 0449	+0. 7	0. 7	......	7. 2395	......	....
		W	−0. 0420	−2. 2	......	......	....	......	....
		W	−0. 0456	+1. 4	......	......	....	......	....
		Mean ..	−0. 0442						
T. B. M. 39 and 39*a*.	56. 57	E	+1. 4625	+3. 0	2. 0	......	8. 7050	......	....
		W	+1. 4685	−3. 0	......	......	....	......	....
		Mean ..	+1. 4655						
*U. S. P. B. M. 5 ...	56. 92	W	−1. 7545	+0. 5	0. 4	5. 7	6. 9510	−0. 1	6. 9509
		W	−1. 7534	−0. 6	......	......	....	......	....
		Mean ..	−1. 7540						
T. B. M. 40 and 40*a*.	57. 68	E	+0. 0320	−0. 5	0. 4	......	8. 7365	......	....
		W	+0. 0301	+1. 4	......	......	....	......	....
		E	+0. 0311	+0. 4	......	......	....	......	....
		W	+0. 0327	−1. 2	......	......	....	......	....
		Mean ..	+0. 0315						
T. B. M. 41 and 41*a*.	58. 62	E	−1. 1105	−0. 3	0. 2	......	7. 6257	......	....
		W	−1. 1111	+0. 3	......	......	....	......	....
		Mean ..	−1. 1108						

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
T.B.M. 53	45.76	S	+1.8580	+0.6	0.4		131.8632			P.
		S	+1.8593	−0.7						F.
		Mean	+1.8586							
T.B.M. 58	48.60	S	+8.0673	−2.9	2.0		139.9276			F.
		S	+8.0614	+3.0						P.
		Mean	+8.0644							
U.S.P.B.M. 12	49.41	S	+5.7337	−0.5	0.4	8.4	145.6608	+0.3	145.6611	P.
		S	+5.7326	+0.6						F.
		Mean	+5.7332							
T.B.M. 61	51.03	S	−5.6617	−1.0	0.6		139.9081			P.
		S	−5.6637	+1.0						F.
		Mean	−5.6627							
T.B.M. 62	51.85	S	+3.0020	−0.6	0.4		142.9995			P.
		S	+3.0007	+0.7						F.
		Mean	+3.0014							
T.B.M. 65	54.50	S	−5.1755	+1.5	1.0		137.8255			P.
		S	−5.1726	−1.4						F.
		Mean	−5.1740							
T.B.M. 67	56.22	S	−2.3581	+5.3	1.8		135.4727			P.
		N	−2.3508	−2.0						S.
		S	−2.3494	−3.4						F.
		Mean	−2.3528							
T.B.M. 69	57.29	S	+3.9197	−1.5	1.0		139.3909			F.
		S	+3.9168	+1.4						P.
		Mean	+3.9182							
T.B.M. 70	58.30	S	−2.4299	−1.3	0.6		136.9597			F.
		S	−2.4330	+1.8						P.
		N	−2.4307	−0.5						S.
		Mean	−2.4312							
U.S.P.B.M. 13	58.91	S	+0.6845	+0.2	0.5	8.7	137.6444	+0.3	137.6447	F.
		N	+0.6834	+1.3						S.
		S	+0.6861	−1.4						S.
		Mean	+0.6847							
T.B.M. 71	59.62	S	+0.1868	+0.6	0.4		137.8318			F.
		N	+0.1880	−0.6						S.
		Mean	+0.1874							
T.B.M. 75	62.62	N	+3.6056	+1.0	0.7		141.4384			S.
		S	+3.6076	−1.0						F.
		Mean	+3.6066							
T.B.M. 76	63.66	S	−0.7366	−0.6	0.4		140.7012			F.
		N	−0.7379	+0.7						S.
		Mean	−0.7372							
T.B.M. 77	64.55	S	−5.5370	−2.0	1.3		135.1622			F.
		N	−5.5409	+1.9						S.
		Mean	−5.5390							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.*	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
T. B. M. 53	73.87	E	+0.4800	−1.6	1.0		8.1959			J.
		W	+0.4769	+1.5						F.
		Mean	+0.4784							
T. B. M. 54	74.79	E	−0.3155	+0.1	0.1		7.8805			J.
		W	−0.3153	−0.1						F.
		Mean	−0.3154							
T. B. M. 55 and 55a.	76.40	E	−0.3096	−0.6	0.4		7.5703			J.
		W	−0.3107	+0.5						F.
		Mean	−0.3102							
T. B. M. 56	78.36	E	+0.3038	−0.1	0.1		7.8740			R.
		W	+0.3036	+0.1						F.
		Mean	+0.3037							
T. B. M. 57	79.53	E	+0.3254	−1.1	0.7		8.1983			R.
		W	+0.3232	+1.1						F.
		Mean	+0.3243							
* U. S. P. B. M. 8	79.10	E	+1.4204			6.2	9.2944	0.0	9.2944	J.
T. B. M. 58 and 58a.	80.87	E	+0.2752	+0.2	0.1		8.4737			R.
		W	+0.2756	−0.2						F.
		Mean	+0.2754							
T. B. M. 59	81.90	E	+1.2051	−0.2	0.1		9.6786			J.
		W	+1.2047	+0.2						F.
		Mean	+1.2049							
T. B. M. 60	83.17	E	−0.6781	+3.6	0.9		9.0041			J.
		W	−0.6723	−2.2						F.
		E	−0.6734	−1.1						J.
		W	−0.6741	−0.4						F.
		Mean	−0.6745							
T. B. M. 61 and 61a.	84.68	E	+2.3275	−0.1	0.3		11.3315			J.
		W	+2.3065	(†)						F.
		E	+2.3267	+0.7						J.
		W	+2.3280	−0.6						F.
		Mean	+2.3274							
* U. S. P. B. M. 9	85.80	E	−0.2700	−1.0	0.6	6.4	11.0605	+0.1	11.0606	J.
		W	−0.2719	+0.9						F.
		Mean	−0.2710							
T. B. M. 62	85.43	E	+0.2808	−0.2	0.1		11.6121			J.
		W	+0.2804	+0.2						F.
		Mean	+0.2806							
T. B. M. 63	86.45	E	+0.1237	+0.1	0.1		11.7359			J.
		W	+0.1240	−0.2						F.
		Mean	+0.1238							
T. B. M. 64	88.28	E	+0.8683	+3.3	1.2		12.6075			J.
		W	+0.8744	−2.8						F.
		E	+0.8721	−0.5						J.
		Mean	+0.8716							

† Rejected.

***Results of precise leveling*—Continued.**

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M*	
B. M. 65	90. 15	E	+0. 9075	+2. 3	0. 9		13. 5173			J.
		W	+0. 9120	−2. 2						F.
		W	+0. 9100	−0. 2						F.
		Mean	+0. 9098							
M. 66 and 66a	91. 66	E	−1. 4738	−1. 2	0. 8		12. 0423			J.
		W	−1. 4762	+1. 2						F.
		Mean	−1. 4750							
P. B. M. 10	91. 91	E	+1. 4717	−0. 9	0. 6	6. 6	13. 5131	+0. 2	13. 5133	R.
		W	+1. 4700	+0. 8						R.
		Mean	+1. 4708							
P. B. M. 11	91. 68	E	+0. 8193	+0. 5	0. 3	6. 6	12. 8621	+0. 2	12. 8623	J.
		E	+0. 8202	−0. 4						F.
		Mean	+0. 8198							
P. B. M. 12	95. 41	E	−2. 7030	−0. 2	0. 5		9. 3391	0. 0	9. 3391	J.
		E	−2. 7016	−1. 6						J.
		W	−2. 7053	+2. 1						F.
		W	−2. 7028	−0. 4						F.
		Mean	−2. 7032							
M. 69 and 69a	97. 66	E	−0. 0470	−0. 9	0. 6		9. 2912			J.
		W	−0. 0488	+0. 9						F.
		Mean	−0. 0479							
M. 70 and 70a.	100. 23	E	+0. 2941	+8. 0	1. 6		9. 5933			R.
		W	+0. 2994	+2. 7						F.
		E	+0. 3040	−1. 9						J.
		E	+0. 3064	−4. 3						J.
		W	+0. 3064	−4. 3						F.
		Mean	+0. 3021							
M. 71	102. 18	E	+2. 5050	+2. 4	0. 9		12. 1007			J.
		W	+2. 5095	−2. 1						F.
		W	+2. 5078	−0. 4						F.
		Mean	+2. 5074							
S. P. B. M. 13	100. 27	E	+0. 1430	−0. 4	0. 3	6. 8	9. 7359	0. 0	9. 7359	J.
		W	+0. 1422	+0. 4						F.
		Mean	+0. 1426							
B. M. 72	103. 54	E	−0. 0177	+0. 7	0. 5		12. 0837			J.
		W	−0. 0163	−0. 7						F.
		Mean	−0. 0170							
B. M. 73 and 73a.	105. 13	E	+2. 6072	+0. 2	0. 2		14. 6911			J.
		W	+2. 6077	−0. 3						F.
		Mean	+2. 6074							
B. M. 74 and 74a.	106. 53	E	+1. 4524	+1. 0	0. 7		16. 1445			J.
		W	+1. 4545	−1. 1						F.
		Mean	+1. 4534							
J. S. P. B. M. 14	106. 65	E	−0. 3790	−0. 4	0. 3	7. 0	15. 7651	+0. 3	15. 7654	J.
		E	- 0. 3799	+0. 5						F.
		Mean	−0. 3794							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 8, Holman...	91.78	S.......	+0.9021	+2.6	1.8	......	135.0967	......	....	S.
		N.......	+0.9074	−2.7	......	......	....	......	....	P.
		Mean..	+0.9047							
B. M. 9, Holman...	92.75	S.......	−1.3792	−3.8	2.6	......	133.7137	......	....	S.
		N.......	−1.3869	+3.9	......	......	....	......	....	P.
		Mean..	−1.3830							
T. B. M. 118.......	93.89	S.......	−0.9828	+3.1	1.1	......	132.7340	......	....	S.
		S.......	−0.9777	−2.0	......	......	....	......	....	S.
		N.......	−0.9786	−1.1	......	......	....	......	....	P.
		Mean..	−0.9797							
*U. S. P. B. M. 19..	....	S.......	−6.5393	0.0	0.0	10.1	126.1947	+0.2	126.1949	P.
		N.......	−6.5393	0.0	......	......	....	......	....	P.
		Mean..	−6.5393							
T. B. M. 119.......	94.68	S.......	+0.6307	+2.1	1.4	......	133.3668	......	....	S.
		N.......	+0.6350	−2.2	......	......	....	......	....	P.
		Mean..	+0.6328							
B. M. 10, Holman..	95.12	S.......	+0.0628	−0.4	0.3	......	133.4292	......	....	F.
		N.......	+0.0620	+0.4	......	......	....	......	....	P.
		Mean..	+0.0624							
B. M. 11, Holman..	97.10	S.......	+1.1273	+2.4	1.6	......	134.5589	......	....	F.
		N.......	+1.1321	−2.4	......	......	....	......	....	P.
		Mean..	+1.1297							
B. M. 12, Holman..	99.36	S.......	−1.8177	−3.7	2.5	......	132.7375	......	....	F.
		N.......	−1.8252	+3.8	......	......	....	......	....	S.
		Mean..	−1.8214							
U. S. P. B. M. 20...	99.40	S.......	−1.6422	+1.2	0.9	10.7	131.0965	+0.2	131.0967	F.
		N.......	−1.6423	+1.3	......	......	....	......	....	S.
		S.......	−1.6384	−2.6	......	......	....	......	....	P.
		Mean..	−1.6410							
T. B. M. 124.......	100.59	S.......	+2.0564	−0.2	0.1	......	133.1527	......	....	F.
		S.......	+2.0560	+0.2	......	......	....	......	....	P.
		Mean..	+2.0562							
B. M. 13, Holman..	100.93	S.......	+0.7609	+0.3	0.2	......	133.9139	......	....	F.
		N.......	+0.7615	−0.3	......	......	....	......	....	P.
		Mean..	+0.7612							
T. B. M. 125.......	101.45	S.......	−1.1589	+1.3	0.9	......	132.7563	......	....	F.
		N.......	−1.1562	−1.4	......	......	....	......	....	P.
		Mean..	−1.1576							
B. M. 14, Holman..	102.49	S.......	−0.4530	+1.8	1.2	......	132.3051	......	....	F.
		N.......	−0.4495	−1.7	......	......	....	......	....	P.
		Mean..	−0.4512							
T. B. M. 126.......	102.82	S.......	−0.2059	+0.1	0.0	......	132.0993	......	....	F.
		N.......	−0.2058	0.0	......	......	....	......	....	P.
		Mean..	−0.2058							

***Results of precise leveling*—Continued.**

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 15, Holman	103. 98	S	+1. 0999	+4. 5	1. 6		133. 2037			F.
		N	+1. 1078	—3. 4						P.
		S	+1. 1056	—1. 2						S.
		Mean	+1. 1044							
U. S. P. B. M. 21	104. 28	S	—3. 1576	+0. 6	0. 4	10. 8	130. 0467	+0. 2	130. 0469	F.
		N	—3. 1576	+0. 6						P.
		S	—3. 1559	—1. 1						S.
		Mean	—3. 1570							
T. B. M. 128	106. 37	S	+4. 9989	+4. 7	2. 6		135. 0503			F.
		S	+5. 0112	—7. 6						S.
		N	+5. 0008	+2. 8						S.
		Mean	+5. 0036							
U. S. P. B. M. 22	107. 16	S	— 4. 3616	+1. 2	0. 8	11. 2	130. 6899	+0. 2	130. 6901	F.
		N	— 4. 3593	—1. 1						S.
		Mean	— 4. 3604							
B. M. 18, Holman	107. 84	S	+0. 9915	+0. 1	0. 1		131. 6815			F.
		N	+0. 9918	—0. 2						S.
		Mean	+0. 9916							
B. M. 19, Holman	108. 94	S	+1. 6970	+1. 4	0. 9		133. 3799			F.
		N	+1. 6998	—1. 4						S.
		Mean	+1. 6984							
B. M. 20, Holman	110. 46	S	—2. 5190	+0. 8	0. 6		130. 8617			F.
		S	—2. 5173	—0. 9						F.
		Mean	—2. 5182							
U. S. P. B. M. 23	110. 74	S	—1. 5524	+0. 8	0. 6	11. 4	129. 3101	+0. 2	129. 3103	F.
		S	—1. 5507	—0. 9						F.
		Mean	—1. 5516							
T. B. M., 130	111. 36	S	+1. 6789	—0. 6	0. 4		130. 9884			F.
		S	+1. 6777	+0. 6						F.
		Mean	+1. 6783							
B. M. 21, Holman	112. 29	S	+0. 8414	—0. 8	0. 5		131. 8290			F.
		N	+0. 8399	+0. 7						P.
		Mean	+0. 8406							
B. M. 22, Holman	113. 90	S	+0. 5794	—0. 6	0. 4		132. 4078			F.
		N	+0. 5782	+0. 6						P.
		Mean	+0. 5788							
B. M. 23, Holman	115. 48	N	+4. 7903	—2. 4	1. 6		137. 1957			F.
		N	+4. 7855	+2. 4						P.
		Mean	+4. 7879							
T. B. M. 133	115. 67	N	—0. 1324	+0. 2	0. 1		137. 0635			F.
		N	—0. 1321	0. 1						P.
		Mean	—0. 1322							
U. S. P. B. M. 24	116. 75	S	—5. 3121	+0. 9	0. 6	11. 5	131. 7523	+0. 2	131. 7525	F.
		N	—5. 3102	—1. 0						P.
		Mean	—5. 3112							

:s of precise leveling—Continued.

:ON, ILL., TO CAIRO, ILL.—Continued.

		Direction	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
			M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
		S	+7. 5875	+3. 5	2. 3	5. 5	141. 4302	+0. 3	141. 4305	F.
		N	+7. 5944	-3. 4	......	......	....	......	....	P.
		Mean ..	+7. 5910							
	:7	S	-9. 6157	-3. 3	2. 2	....	131. 8112	......	....	F.
		N	-9. 6222	+3. 2	......	......	....	......	....	P.
		Mean ..	-9. 6190							
	14. 38	N	+0. 1379	+0. 7	0. 5	......	131. 9498	......	....	P.
		S	+0. 1393	-0. 7	......	......	....	......	....	F.
		Mean ..	+0. 1386							
	15. 39	S	-0. 8453	+4. 0	2. 0	......	131. 1085	......	....	F.
		N	-0. 8355	-5. 8	......	......	....	......	....	P.
		N	-0. 8431	+1. 8	......	......	....	......	....	F.
		Mean ..	-0. 8413							
......	15. 88	S	+3. 9243	+0. 8	0. 5	6. 3	135. 0336	+0. 3	135. 0339	F.
		N	+3. 9259	-0. 8	......	......	....	......	....	P.
		Mean ..	+3. 9251							
....	18. 02	S	-1. 1456	-1. 2	0. 8	......	133. 8868	......	....	F.
		N	-1. 1480	+1. 2	......	......	....	......	....	P.
		Mean ..	-1. 1468							
......	19. 13	N	-2. 4954	-4. 8	2. 1	......	131. 3806	......	....	P.
		S	-2. 5059	+5. 7	......	......	....	......	....	F.
		N	-2. 4994	-0. 8	......	......	....	......	....	F.
		Mean ..	-2. 5002							
....	19. 78	S	+0. 2852	-2. 0	1. 3	......	131. 6698	......	....	F.
		N	+0. 2813	+1. 9	......	......	....	......	....	P.
		Mean ..	+0. 2832							
.3	21. 13	N	-1. 6478	-1. 6	1. 1	......	130. 0204	......	....	P.
		S	- 1. 6510	+1. 6	......	......	....	......	....	F.
		Mean ..	-1. 6494							
M. 25	22. 29	S	+5. 4806	-1. 0	0. 4	......	135. 5000	......	....	F.
		N	+5 4797	-0. 1	......	......	....	......	....	P.
		S	+5. 4786	+1. 0	......	......	....	......	....	F.
		Mean ..	+5. 4796							
s. P. B. M. 7 ...	....	S	+8. 2185	-0. 7	0. 4	6. 9	143. 7178	+0. 3	143. 7181	P.
		N	+8. 2172	+0. 6	......	......	....	......	....	P.
		Mean ..	+8. 2178							
., M. 27	23. 77	S	-4. 7250	+2. 0	1. 7	......	130. 7779	......	....	F.
		N	-4. 7169	-5 2	......	......	....	......	....	P.
		N	-4. 7243	+2. 2	......	......	....	......	....	F.
		Mean ..	-4. 7221							
. M. 28	24. 93	S	-0 6382	-1. 2	0. 8	......	130. 1385	......	....	F.
		N	- 0. 6407	+1. 3	......	......	....	......	....	P.
		Mean ..	-0. 6394							
s. P. B. M. 8	27. 70	N	+6. 8074	+0. 6	0. 4	7. 1	136. 9465	+0. 3	136. 9468	P.
		S	+6. 8080	-0. 6	......	......	....	......	....	F.
		Mean ..	+6. 8080							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
U. S. P. B. M. 29	151.29	N	+11.2023	−1.3	0.9	13.0	131.0372	+0.2	131.0374	P.
		S	+11.1997	+1.3						F.
		Mean	+11.2010							
T. B. M. 167	151.66	S	−7.4074	−0.2	0.2		123.6296			F.
		S	−7.4079	+0.3						F.
		Mean	−7.4076							
B. M. 45, Holman	153.51	S	−3.3295	+3.3	2.2		120.3034			F.
		S	−3.3229	−3.3						F.
		Mean	−3.3262							
T. B. M. 170	154.62	S	−1.6221	−0.4	0.3		118.6809			F.
		S	−1.6229	+0.4						F.
		Mean	−1.6225							
B. M. 46, Holman	155.18	S	+2.8847	+1.0	0.7		121.5666			F.
		N	+2.8867	−1.0						F.
		Mean	+2.8857							
T. B. M. 171	155.91	S	−3.0724	−0.8	0.5		118.4934			F.
		N	−3.0740	+0.8						P.
		Mean	−3.0732							
*U. S. P. B. M. 30			+6.1939	−0.4	0.3	13.2	124.6869	+0.2	124.6871	P.
			+6.1931	+0.4						P.
		Mean	+6.1935							
B. M. 48, Holman	158.29	S	+1.5794	+2.6	1.7		120.0754			F.
		N	+1.5846	−2.6						P.
		Mean	+1.5820							
B. M. 50, Holman	160.77	S	−1.1472	+0.6	0.4		118.9288			F.
		N	−1.1459	−0.7						P.
		Mean	−1.1466							
U. S. P. B. M. 31	161.84	S	+9.9707	+4.6	1.6	13.4	128.9041	+0.2	128.9043	F.
		N	+9.9784	−3.1						F.
		N	+9.9769	−1.6						P.
		Mean	+9.9753							
B. M. 51, Holman	162.14	S	−8.9848	−0.6	0.4		119.9187			F.
		N	−8.9860	+0.6						F.
		Mean	−8.9854							
T. B. M. 173	162.48	S	−1.5273	+0.7	0.5		118.3921			F.
		N	−1.5258	−0.8						F.
		Mean	−1.5266							
T. B. M. 174	162.75	S	−2.7524	−1.3	0.9		115.6384			F.
		N	−2.7550	+1.3						P.
		Mean	−2.7537							
T. B. M. 174½	162.80	S	+1.1607	+0.1	0.0		116.7992			P.
		N	+1.1608	0.0						P.
		Mean	+1.1608							

***Results of precise leveling*—Continued.**

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
53, Holman	164.88	N	+8.7970	−1.4	1.0		125.5948			P.
		S	+8.7941	+1.5						F.
		Mean	+8.7956							
54, Holman	165.88	N	−1.5969	+3.1	2.1		124.0010			P.
		S	−1.5906	−3.2						F.
		Mean	−1.5938							
P. B. M. 32	166.06	N	+1.1535	−0.4	0.3	13.7	125.1541	+0.2	125.1543	P.
		S	+1.1527	+0.4						F.
		Mean	+1.1531							
M. 176	166.92	S	+1.0474	+0.2	0.2		126.2017			F.
		N	+1.0479	−0.3						P.
		Mean	+1.0476							
S. P. B. M. 33			+2.1128	+0.4	0.3	13.7	128.3149	+0.2	128.3151	P.
			+2.1137	−0.5						P.
		Mean	+2.1132							
M. 180	171.42	S	−4.6547	+5.7	3.8		121.5327			F.
		N	−4.6432	−5.8						P.
		Mean	−4.6490							
P. B. M. 34	173.85	S	+1.6958	+5.5	2.0	14.3	123.2540	+0.2	123.2542	F.
		N	+1.7020	−0.7						F.
		N	+1.7061	−4.8						P.
		Mean	+1.7013							
B. M. 182	175.24	S	−0.2147	+0.7	0.3		123.0400			F.
		N	−0.2132	−0.8						P.
		S	−0.2141	+0.1						P.
		Mean	−0.2140							
B. M. 183	175.74	S	+1.4162	−0.8	1.0		124.4554			F.
		N	+1.4101	+5.3						P.
		S	+1.4198	−4.4						P.
		Mean	+1.4154							
B. M. 184	176.03	S	−3.3225	−0.6	0.4		121.1323			F.
		N	−3.3237	+0.6						P.
		Mean	−3.3231							
B. M. 188	181.04	S	+2.5663	+4.3	2.9		123.7029			F.
		N	+2.5749	−4.3						P.
		Mean	+2.5706							
S. P. B. M. 35	181.47	S	+0.9589	−0.3	0.2	14.7	124.6615	+0.2	124.6617	F.
		N	+0.9583	+0.3						P.
		Mean	+0.9586							
S. P. B. M. 36			+2.1172	−0.2	0.1	14.7	126.7785	+0.2	126.7787	P.
			+2.1168	+0.2						P.
		Mean	+2.1170							
B. M. 190	181.48	S	−0.2277	+0.3	0.2		124.4341			F.
		N	−0.2271	−0.3						F.
		Mean	−0.2274							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*
*U. S. P. B. M. 14		N	+0.9570	+0.6	0.4	8.8	136.1198	+0.3	136.1201
		S	+0.9581	−0.5					
		Mean	+0.9576						
*B. M. on high-service chimney, Saint Louis water-works.		N	−1.2800	−0.1	0.1		134.8397		
		S	−1.2802	+0.1					
		Mean	−1.2801						
*B. M. on low-service chimney, Saint Louis water-works.		N	+0.4872	−2.6	1.7		135.3243		
		S	+0.4820	+2.6					
		Mean	+0.4846						
*B. M. on cotton-wood tree, Saint Louis water-works.		N	−2.2877	−0.7	0.4		133.0359		
		S	−2.2890	+0.6					
		Mean	−2.2884						
*89-foot mark of water-gauge at Saint Louis water-works.		N	−4.2622	+0.7	0.5		128.7744		
		S	−4.2608	−0.7					
		Mean	−4.2615						
T. B. M. 81	66.52	S	+3.0183	−0.9	0.6		138.1796		
		N	+3.0166	+0.8					
		Mean	+3.0174						
T. B. M. 83	67.84	S	+4.8850	+2.2	1.5		143.0624		
		S	+4.8805	−2.3					
		Mean	+4.8828						
T. B. M. 85	68.66	S	+8.0560	+3.3	1.1		151.1217		
		N	+8.0615	−2.2					
		S	+8.0605	−1.2					
		Mean	+8.0593						
T. B. M. 87	69.82	S	−18.9394	+1.0	0.6		132.1833		
		N	−18.9375	−0.9					
		Mean	−18.9384						
*U. S. P. B. M. 15		S	+0.9093	+1.0	0.3	9.1	133.0936	+0.2	133.0938
		S	+0.9108	−0.5					
		N	+0.9109	−0.6					
		Mean	+0.9103						
City Directrix, Saint Louis, Mo.	70.51	S	+0.0917	−1.0	0.7	9.1	132.2740	+0.2	132.2742
		N	+0.0897	+1.0					
		Mean	+0.0907						
*30-foot mark of water-gauge at Saint Louis, Mo.							131.1331		
T. B. M. 89	71.37	S	+0.8749	+0.9	0.6		133.1498		
		N	+0.8766	−0.8					
		Mean	+0.8758						
T. B. M. 92	73.17	S	+1.0174	+0.9	0.6		134.1681		
		N	+1.0192	−0.9					
		Mean	+1.0183						

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 96	75. 62	S	+22. 8696	+0. 6	0. 4	......	157. 0383	......	....	F.
		N	+22. 8707	−0. 5	......	......	....	......	....	S.
		Mean ..	+22. 8702							
U. S. P. B. M. 16 ...	77. 60	S	+2. 3069	+0. 5	0. 3	9. 2	159. 3457	+0. 4	159. 3461	F.
		N	+2. 3079	−0. 6	......	......	....	......	....	S.
		Mean ..	+2. 3074							
T. B. M. 100	79. 90	S	−0. 4785	−0. 3	0. 2	......	158. 8669	......	....	F.
		S	−0. 4790	+0. 2	......	......	....	......	....	P.
		Mean ..	−0. 4788							
U. S. P. B. M. 17 ...	82. 43	S	−20. 1856	+0. 4	0. 2	9. 2	138. 6817	+0. 3	138. 6820	F.
		S	−20. 1849	−0. 3	......	......	....	......	....	P.
		Mean ..	−20. 1852							
T. B. M. 104	82. 44	S	−0. 8865	+0 2	0. 1	......	137. 7954	......	....	F.
		N & S ...	−0. 8861	−0. 2	......	......	....	......	....	P.
		Mean ..	−0. 8863							
*B. M. 1, Holman ..	....	S	−3. 2617	+1. 1	0. 7	......	134. 5348	......	....	F.
		N	−3. 2595	−1. 1	......	......	....	......	....	F.
		Mean ..	−3. 2606							
T. B. M. 105	83. 78	S	−6. 9739	−1. 0	0. 7	......	130. 8205	......	....	F.
		N	−6. 9759	+1. 0	......	......	....	......	....	P.
		Mean ..	−6. 9749							
T. B. M. 106	84. 59	S	+29. 7024	−1. 3	0. 9	......	160. 5216	......	....	F.
		N	+29. 6998	+1. 3	......	......	....	......	....	P.
		Mean ..	+29. 7011							
T. B. M. 109	86. 73	S	−7. 7744	+2. 7	1. 8	......	152. 7499	......	....	F.
		N	−7. 7690	−2. 7	......	......	....	......	....	P.
		Mean ..	−7. 7717							
T. B. M. 112	88. 33	S	+4. 0928	−2. 0	1. 3	......	156. 8407	......	....	F.
		N	+4. 0888	+2. 0	......	......	....	......	....	S.
		Mean ..	+4. 0908							
*U. S. P. B. M. 18 ..	....	S	+0. 0579	+0. 2	0. 1	9. 5	156. 8988	+0. 4	156. 8992	F.
		N	+0. 0584	−0. 3	......	......	....	......	....	F.
		S	+0. 0581	0. 0	......	......	....	......	....	P.
		Mean ..	+0. 0581							
B. M. 6, Holman ...	89. 18	S	−24. 4483	+0. 1	0. 0	......	132. 3925	......	....	F.
		N	−24. 4482	0. 0	......	......	....	......	....	P.
		Mean ..	−24. 4482							
T. B. M. 114	89. 63	S	+1. 3173	+1. 6	1. 0	......	133. 7113	......	....	F.
		N	+1. 3203	−1. 5	......	......	....	......	....	P.
		Mean ..	+1. 3188							
B. M. 7, Holman ...	90. 90	S.	+0. 4811	−0. 4	0. 2	......	134. 1920	......	....	S.
		N	+0. 4804	+0. 3	......	......	....	......	....	P.
		Mean ..	+0. 4807							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*
B. M. 8, Holman	91.78	S	+0.9021	+2.6	1.8	......	135.0967	......	....
		N	+0.9074	−2.7	......	......	....	......	....
		Mean	+0.9047						
B. M. 9, Holman	92.75	S	−1.3792	−3.8	2.6	......	133.7137	......	....
		N	−1.3869	+3.9	......	......	....	......	....
		Mean	[illegible]						
T. B. M. 118	93.8[illegible]	[illegible]	[illegible]	[illegible]	1.1	......	132.7340	......	....
		[illegible]	[illegible]	[illegible]	......	......	....	......	....
		[illegible]	[illegible]	[illegible]	......	......	....	......	....
		Mean	[illegible]						
*U. S. P. B. M. 19	....	S	[illegible]	[illegible]	0.0	10.1	126.1947	+0.2	126.1949
		N	[illegible]	[illegible]	......	......	....	......	....
		Mean	[illegible]						
T. B. M. 119	94.68	S	[illegible]	[illegible]	1.4	......	133.3668	......	....
		N	[illegible]	[illegible]	......	......	....	......	....
		Mean	[illegible]						
B. M. 10, Holman	95 12	S	[illegible]	[illegible]	0.3	......	133.4292	......	....
		N	[illegible]	[illegible]	......	......	....	......	....
		Mean	[illegible]						
B. M. 11, Holman	97.10	S	+1.1273	+2.4	1.6	......	134.5589	......	....
		N	+1.1321	−2.4	......	......	....	......	....
		Mean	+1.1297						
B. M. 12, Holman	99.36	S	−1.8177	−3.7	2.5	......	132.7375	......	....
		N	−1.8252	+3.8	......	......	....	......	....
		Mean	−1.8214						
U. S. P. B. M. 20	99.40	S	−1.6422	+1.2	0.9	10.7	131.0965	+0.2	131.0967
		N	−1.6423	+1.3	......	......	....	......	....
		S	−1.6384	−2.6	......	......	....	......	....
		Mean	−1.6410						
T. B. M. 124	100.59	S	+2.0564	−0.2	0.1	......	133.1527	......	....
		S	+2.0560	+0.2	......	......	....	......	....
		Mean	+2.0562						
B. M. 13, Holman	100.93	S	+0.7609	+0.3	0.2	......	133.9139	......	....
		N	+0.7615	−0.3	......	......	....	......	....
		Mean	+0.7612						
T. B. M. 125	101.45	S	−1.1589	+1.3	0.9	......	132.7563	......	....
		N	−1.1562	−1.4	......	......	....	......	....
		Mean	−1.1576						
B. M. 14, Holman	102.49	S	−0.4530	+1.8	1.2	......	132.3051	......	....
		N	−0.4495	−1.7	......	......	....	......	....
		Mean	−0.4512						
T. B. M. 126	102.82	S	−0.2059	+0.1	0.0	......	132.0993	......	....
		N	−0.2058	0.0	......	......	....	......	....
		Mean	−0.2058						

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
B. M. 15, Holman	103.98	S	+1.0999	+4.5	1.6		133.2037			F.
		N	+1.1078	—3.4						P.
		S	+1.1056	—1.2						S.
		Mean	+1.1044							
U. S. P. B. M. 21	104.28	S	—3.1576	+0.6	0.4	10.8	130.0467	+0.2	130.0469	F.
		N	—3.1576	+0.6						P.
		S	—3.1559	—1.1						S.
		Mean	—3.1570							
T. B. M. 128	106.37	S	+4.9989	+4.7	2.6		135.0503			F.
		S	+5.0112	—7.6						S.
		N	+5.0008	+2.8						S.
		Mean	+5.0036							
U. S. P. B. M. 22	107.16	S	— 4.3616	+1.2	0.8	11.2	130.6899	+0.2	130.6901	F.
		N	— 4.3593	—1.1						S.
		Mean	— 4.3604							
B. M. 18, Holman	107.84	S	+0.9915	+0.1	0.1		131.6815			F.
		N	+0.9918	—0.2						S.
		Mean	+0.9916							
B. M. 19, Holman	108.94	S	+1.6970	+1.4	0.9		133.3799			F.
		N	+1.6998	—1.4						S.
		Mean	+1.6984							
B. M. 20, Holman	110.46	S	—2.5190	+0.8	0.6		130.8617			F.
		S	—2.5173	—0.9						F.
		Mean	—2.5182							
U. S. P. B. M. 23	110.74	S	—1.5524	+0.8	0.6	11.4	129.3101	+0.2	129.3103	F.
		S	—1.5507	—0.9						F.
		Mean	—1.5516							
T. B. M., 130	111.36	S	+1.6789	—0.6	0.4		130.9884			F.
		S	+1.6777	+0.6						F.
		Mean	+1.6783							
B. M. 21, Holman	112.29	S	+0.8414	—0.8	0.5		131.8290			F.
		N	+0.8399	+0.7						P.
		Mean	+0.8406							
B. M. 22, Holman	113.90	S	+0.5794	—0.6	0.4		132.4078			F.
		N	+0.5782	+0.6						P.
		Mean	+0.5788							
B. M. 23, Holman	115.48	N	+4.7903	—2.4	1.6		137.1957			F.
		N	+4.7855	+2.4						P.
		Mean	+4.7879							
T. B. M. 133	115.67	N	—0.1324	+0.2	0.1		137.0635			F.
		N	—0.1321	0.1						P.
		Mean	—0.1322							
U. S. P. B. M. 24	116.75	S	—5.3121	+0.9	0.6	11.5	131.7523	+0.2	131.7525	F.
		N	—5.3102	—1.0						P.
		Mean	—5.3112							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 134	117.63	S	−8.9996	−2.5	1.0		122.7502			F.
		S	−9.0046	+2.5						S.
		S	−9.0021	0.0						S.
		Mean	−9.0021							
B. M. 25, Holman	118.25	S	+2.0595	+0.2	0.1		124.8099			S.
		S	+2.0599	−0.2						F.
		Mean	[illegible]							
T. B. M. 135	119.26	S	[illegible]	[illegible]	[illegible]		122.4959			S.
		S	[illegible]	[illegible]						F.
		Mean	[illegible]							
T. B. M. 136	120.14	S	[illegible]	[illegible]	[illegible]		122.0847			S.
		S	[illegible]	[illegible]						F.
		N	[illegible]	[illegible]						P.
		Mean	[illegible]							
T. B. M. 138	121.05	S	[illegible]	[illegible]	[illegible]		124.4659			S.
		S	[illegible]	[illegible]						F.
		N	[illegible]	[illegible]						P.
		Mean	[illegible]							
T. B. M. 139	121.89	S	[illegible]	[illegible]	[illegible]		123.9743			S.
		S	[illegible]	[illegible]						F.
		Mean	−0.4916							
T. B. M. 141	122.97	S	+3.8433	+4.0	1.5		127.8216			F.
		N	+3.8512	−3.9						P.
		S	−3.8473	0.0						P.
		Mean	+3.8473							
T. B. M. 142	123.72	S	−0.6375	−1.1	0.8		127.1830			F.
		N	−0.6398	+1.2						P.
		Mean	−0.6386							
U. S. P. B. M. 25	125.22	S	−3.5437	−0.3	0.2	12.0	123.6390	+0.2	123.6392	F.
		N	−3.5442	+0.2						P.
		Mean	−3.5440							
B. M. 31, Holman	126.96	S	−0.1413	−2.9	1.9		123.4948			F.
		N	−0.1471	+2.9						P.
		Mean	−0.1442							
B. M. 32, Holman	128.66	S	−0.6353	+2.5	1.7		122.8620			F.
		N	−0.6302	−2.6						P.
		Mean	−0.6328							
T. B. M. 149	129.58	S	−2.0903	−0.3	0.2		120.7714			F.
		N	−2.0908	+0.2						P.
		Mean	−2.0906							
B. M. 33, Holman	130.06	S	+2.3763	−1.3	0.8		123.1464			F.
		N	+2.3738	+1.2						P.
		Mean	+2.3750							
B. M. 34, Holman	131.43	S	−1.3996	+2.4	1.6		121.7492			F.
		N	−1.3947	−2.5						P.
		Mean	−1.3972							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 35, Holman	132.91	S	+1.0984	−1.0	0.7		122.8466			F.
		N	+1.0964	+1.0						P.
		Mean	+1.0974							
*U. S. P. B. M. 26			+1.8112	−0.2	0.1	12.4	124.6576	+0.2	124.6578	P.
			+1.8109	+0.1						P.
		Mean	+1.8110							
U. S. P. B. M. 27	134.63	N	+3.8334	−1.2	0.8	12.4	126.6788	+0.2	126.6790	P.
		S	+3.8311	+1.1						F.
		Mean	+3.8322							
*34-foot mark of water-gauge at Rush Tower, Mo.							123.9558			
T. B. M. 153	136.81	S	−3.3630	+1.2	0.8		123.3170			F.
		S	−3.3606	−1.2						P.
		Mean	−3.3618							
T. B. M. 156	139.82	S	+0.4072	+0.5	0.3		123.7247			F.
		S	+0.4082	−0.5						P.
		Mean	+0.4077							
T. B. M. 157	140.75	S	−1.0716	+4.5	1.7		122.6576			F.
		N	−1.0669	−0.2						F.
		S	−1.0629	−4.2						P.
		Mean	−1.0671							
T. B. M. 160	142.28	S	+0.8712	0.0	0.0		123.5288			F.
		N	+0.8711	+0.1						F.
		Mean	+0.8712							
T. B. M. 163	143.85	S	−0.8113	+1.7	1.1		122.7192			F.
		N	−0.8079	−1.7						F.
		Mean	−0.8096							
U. S. P. B. M. 28	144.41	S	−1.1708	+0.2	0.2	12.6	121.5486	+0.1	121.5487	F.
		N	−1.1703	−0.3						F.
		Mean	−1.1706							
B. M. 40, Holman	145.64	S	−1.7538	−1.8	2.8		119.7930			F.
		S	−1.7622	+6.6						F.
		N	−1.7508	−4.8						F.
		Mean	−1.7556							
B. M. 41, Holman	146.40	S	+1.4165	+1.3	0.9		121.2108			F.
		S	+1.4191	−1.3						F.
		Mean	+1.4178							
B. M. 43, Holman	149.72	S	−2.8154	−1.0	0.6		118.3944			F.
		N	−2.8173	+0.9						P.
		Mean	−2.8164							
B. M. 44, Holman	150.97	N	+1.4443	−2.5	1.6		119.8362			P.
		S	+1.4394	+2.4						F.
		Mean	+1.4418							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 29 ...	151.29	N	+11.2023	−1.3	0.9	13.0	131.0372	+0.2	131.0374	P.
		S	+11.1997	+1.3	......	......	....	......	....	F.
		Mean..	+11.2010							
T. B. M. 167	151.66	S	−7.4074	−0.2	0.2	......	123.6296	......	....	F.
		S	−7.4079	+0.3	......	......	....	......	....	F.
		M[illegible]	[illegible]							
B. M. 45, Holman..	153.51	S [illegible]	[illegible]	[illegible]	[illegible]	......	120.3034	......	....	F.
		S [illegible]	[illegible]	[illegible]	[illegible]	......	....	......	....	F.
		Mean..	−[illegible]							
T. B. M. 170	154.62	S	−1[illegible]	−0.4	[illegible]	......	118.6809	......	....	P.
		S	−1[illegible]	+0.4	......	......	....	......	....	P.
		Mean..	−1[illegible]							
B. M. 46, Holman..	155.18	S	+[illegible]	+1.0	0.7	......	121.5666	......	....	F.
		N	+[illegible]	−1.0	......	......	....	......	....	F.
		Mean..	+2.8857							
T. B. M. 171	155.91	S	−3.0724	−0.8	0.5	......	118.4934	......	....	F.
		N	−3.0740	+0.8	......	......	....	......	....	P.
		Mean..	−3.0732							
*U. S. P. B. M. 30 ..	....	....	+6.1939	−0.4	0.3	13.2	124.6869	+0.2	124.6871	P.
		....	+6.1931	+0.4	......	......	....	......	....	P.
		Mean..	+6.1935							
B. M. 48, Holman..	158.29	S	+1.5794	+2.6	1.7	......	120.0754	......	....	F.
		N	+1.5846	−2.6	......	......	....	......	....	P.
		Mean..	+1.5820							
B. M. 50, Holman..	160.77	S	−1.1472	+0.6	0.4	......	118.9288	......	....	F.
		N	−1.1459	−0.7	......	......	....	......	....	P.
		Mean..	−1.1466							
U. S. P. B. M. 31 ...	161.84	S	+9.9707	+4.6	1.6	13.4	128.9041	+0.2	128.9043	F.
		N	+9.9784	−3.1	......	......	....	......	....	F.
		N	+9.9769	−1.6	......	......	....	......	....	P.
		Mean..	+9.9753							
B. M. 51, Holman..	162.14	S	−8.9848	−0.6	0.4	......	119.9187	......	....	F.
		N	−8.9860	+0.6	......	......	....	......	....	F.
		Mean..	−8.9854							
T. B. M. 173	162.48	S	−1.5273	+0.7	0.5	......	118.3921	......	....	F.
		N	−1.5258	−0.8	......	......	....	......	....	F
		Mean..	−1.5266							
T. B. M. 174	162.75	S	−2.7524	−1.3	0.9	......	115.6384	......	....	F.
		N	−2.7550	+1.3	......	......	....	......	....	P.
		Mean..	−2.7537							
T. B. M. 174½	162.80	S	+1.1607	+0.1	0.0	......	116.7992	......	....	P.
		N	+1.1608	0.0	......	......	....	......	....	P.
		Mean..	+1.1608							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
3, Holman	164.88	N	+8.7970	—1.4	1.0		125.5948			P.
		S	+8.7941	+1.5						F.
		Mean	+8.7956							
4. Holman	165.88	N	—1.5969	+3.1	2.1		124.0010			P.
		S	—1.5906	—3.2						F.
		Mean	—1.5938							
P. B. M. 32	166.06	N	+1.1535	—0.4	0.3	13.7	125.1541	+0.2	125.1543	P.
		S	+1.1527	+0.4						F.
		Mean	+1.1531							
M. 176	166.92	S	+1.0474	+0.2	0.2		126.2017			F.
		N	+1.0479	—0.3						P.
		Mean	+1.0476							
P. B. M. 33			+2.1128	+0.4	0.3	13.7	128.3149	+0.2	128.3151	P.
			+2.1137	—0.5						P.
		Mean	+2.1132							
M. 180	171.42	S	—4.6547	+5.7	3.8		121.5527			F.
		N	—4.6432	—5.8						P.
		Mean	—4.6490							
P. B. M. 34	173.85	S	+1.6958	+5.5	2.0	14.3	123.2540	+0.2	123.2542	F.
		N	+1.7020	—0.7						F.
		N	+1.7061	—4.8						P.
		Mean	+1.7013							
M. 182	175.24	S	—0.2147	+0.7	0.3		123.0400			F.
		N	—0.2132	—0.8						P.
		S	—0.2141	+0.1						P.
		Mean	—0.2140							
B. M. 183	175.74	S	+1.4162	—0.8	1.9		124.4554			F.
		N	+1.4101	+5.3						P.
		S	+1.4198	—4.4						P.
		Mean	+1.4154							
B. M. 184	176.03	S	—3.3225	—0.6	0.4		121.1323			F.
		N	—3.3237	+0.6						P.
		Mean	—3.3231							
B. M. 188	181.04	S	+2.5663	+4.3	2.9		123.7029			F.
		N	+2.5749	—4.3						P.
		Mean	+2.5706							
S. P. B. M. 35	181.47	S	+0.9589	—0.3	0.2	14.7	124.6615	+0.2	124.6617	F.
		N	+0.9583	+0.3						P.
		Mean	+0.9586							
U. S. P. B. M. 36			+2.1172	—0.2	0.1	14.7	126.7785	+0.2	126.7787	P.
			+2.1168	+0.2						P.
		Mean	+2.1170							
B. M. 190	181.48	S	—0.2277	+0.3	0.2		124.4341			F.
		N	—0.2271	—0.3						F.
		Mean	—0.2274							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 345	309. 06	N	—1. 0015	+0. 7	0. 4		103. 4036			F.
		S	—1. 0002	—0. 6						F.
		Mean	—1. 0008							
*U. S. P. B. M. 59		N	+15. 3483	+2. 0	0. 7	20. 8	118. 7539	+0. 1	118. 7540	F.
		S	+15. 3515	—1. 2						F.
		S	+15. 3512	—0. 9						F.
		Mean	+15. 3508							
*U. S. P. B. M. 60		N	—8. 2528	—2. 0	1. 3	20. 9	110. 5031	+0. 1	110. 5032	F.
		S	—8. 2488	+2. 0						F.
		Mean	—8. 2508							
*U. S. P. B. M. 61		S	+6. 1278	—0. 3	0. 2	20. 9	116. 6306	+0. 1	116. 6307	F.
		N	+6. 1272	+0. 3						F.
		Mean	+6. 1275							
*H. W. mark, 1858, Commerce, Mo.							107. 1321			
T. B. M. 349	309. 15	N	—0. 7183	+0. 1	0. 1		102. 6854			F.
		S	—0. 7180	—0. 2						F.
		Mean	—0. 7182							
T. B. M. 350	309. 54	S	+1. 5212	—0. 1	1. 3		104. 2065			F.
		N	+1. 5178	+3. 3						F.
		S	+1. 5243	—3. 2						F.
		Mean	+1. 5211							
T. B. M. 351	309. 66	S	—0. 4190	+2. 4	0. 0		103. 7899			F.
		N	—0. 4163	—0. 3						F.
		S	—0. 4159	—0. 7						F.
		N	—0. 4157	—0. 9						F.
		S	—0. 4163	—0. 3						F.
		Mean	—0. 4166							
T. B. M. 353	310. 06	S	—0. 7842	—2. 9	1. 0		103. 0028			F.
		N	—0. 7888	+1. 7						F.
		S	—0. 7883	+1. 2						F.
		Mean	—0. 7871							
T. B. M. 355	310. 14	S	+5. 3542	+0. 5	0. 3		108. 3575			F.
		N	+5. 3552	—0. 5						F.
		Mean	+5. 3547							
*U. S. P. B. M. 62		S	—3. 7507	+1. 0	0. 7	20. 9	104. 6078	0. 0	104. 6078	F.
		N	—3. 7487	—1. 0						F.
		Mean	—3. 7497							
*U. S. P. B. M. 63		S	+4. 1882	+0. 7	0. 5	20. 9	108. 7967	0. 0	108. 7967	F.
		N	+4. 1896	—0. 7						F.
		Mean	+4. 1889							
T. B. M. 357	313. 07	S	—1. 4364	+0. 6	0. 4		106. 9217			F.
		N	—1. 4353	—0. 5						F.
		Mean	—1. 4358							
T. B. M. 359	314. 34	S	—0. 9348	—1. 4	1. 3		105. 9855			F.
		N	—0. 9400	+3. 8						F.
		S	—0. 9339	—2. 3						F.
		Mean	—0. 9362							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
. P. B. M. 39	....	S	+2.5103	−0.3	0.2	15.2	122.2671	+0.2	122.2673	F.
		N	+2.5096	+0.4	......	......	....	......	....	F.
		Mean..	+2.5100							
M. 208	194.69	S	+6.8116	−0.2	0.1	......	120.4908	......	....	F.
		N	+6.8113	+0.1	......	......	....	......	....	F.
		Mean..	+6.8114							
M. 209	195.91	S	−0.3889	+3.2	2.1	......	120.1051	......	....	F.
		N	−0.3795	−6.2	......	......	....	......	....	F.
		S	−0.3887	+3.0	......	......	....	......	....	F.
		Mean..	−0.3857							
M. 211	197.97	N	−0.9232	+4.1	2.7	......	119.1860	......	....	P.
		S	−0.9150	−4.1	......	......	....	......	....	P.
		Mean..	−0.9191							
M. 213	198.95	N	−0.1146	+0.6	0.4	......	119.0720	......	....	P.
		S	−0.1133	−0.7	......	......	....	......	....	P.
		Mean..	−0.1140							
M. 215	201.46	N	−1.2221	+0.5	0.3	......	117.8504	......	....	P.
		S	−1.2211	−0.5	......	......	....	......	....	F.
		Mean..	−1.2216							
S. P. B. M. 40..	....	S	+0.2030	−1.6	1.1	15.6	118.0518	+0.1	118.0519	F.
		N	+0.1997	+1.7	......	......	....	......	....	F.
		Mean..	+0.2014							
. M. 217	202.73	S	+1.8685	+2.6	1.7	......	119.7215	......	....	F.
		N	+1.8737	−2.6	......	......	....	......	....	F.
		Mean..	+1.8711							
. M. 218	203.97	S	−1.3034	+2.4	2.1	......	118.4205	......	....	F.
		N	−1.2948	−6.2	......	......	....	......	....	F.
		S	−1.3049	+3.9	......	......	....	......	....	F.
		Mean..	−1.3010							
. M. 219	204.52	S	+0.7416	+0.6	0.2	......	119.1627	......	....	F.
		N	+0.7424	−0.2	......	......	....	......	....	P.
		S	+0.7427	−0.5	......	......	....	......	....	P.
		Mean..	+0.7422							
B. M. 221	205.73	S	−0.3961	+3.1	1.1	......	118.7697	......	....	F.
		N	−0.3918	−1.2	......	......	....	......	....	P.
		S	−0.3910	−2.0	......	......	....	......	....	P.
		Mean..	−0.3930							
B. M. 223	206.93	S	−0.9955	+1.5	1.0	......	117.7757	......	....	F.
		N	−0.9924	−1.6	......	......	....	......	....	P.
		Mean..	−0.9940							
. S. P. B. M. 41..	....	S	−1.2012	+1.4	1.3	15.9	116.5759	+0.1	116.5760	F.
		N	−1.1944	−5.4	......	......	....	......	....	F.
		S	−1.2004	+0.6	......	......	....	......	....	P.
		N	−1.2030	+3.2	......	......	....	......	....	P.
		Mean..	−1.1998							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 224	208. 04	S	+0. 8431	—1. 3	0. 9		118. 6175			P.
		N.	+0. 8405	+1. 3						P.
		Mean..	+0. 8418							
T. B. M. 227	210. 12	S	—2. 5950	+4. 8	3. 2		116. 0273			P.
		N.	—2. 5855	—4. 7						P.
		Mean..	[illegible]							
T. B. M. 229	212. 17	S	[illegible]	[illegible]	[illegible]		117. 2931			P.
		N.	[illegible]	[illegible]						P.
		Mean..	[illegible]							
T. B. M. 232	214. 53	S	[illegible]	+3. 7	2. 5		115. 6543			F.
		N.	[illegible]	—3. 8						F.
		Mean..	[illegible]							
T. B. M. 233	214. 96	S	+[illegible]	[illegible]	[illegible]		117. 4064			F.
		N.	+[illegible]	[illegible]						F.
		N.	+[illegible]	[illegible]						F.
		Mean..	[illegible]							
T. B. M. 235	216. 97	[illegible]	[illegible]	[illegible]	[illegible]		117. 3568			F.
		[illegible]	[illegible]	[illegible]						F.
		[illegible]	[illegible]	[illegible]						F.
		Mean..	[illegible]							
T. B. M. 236	218. 02	S	—1. 0710	+8. 2	2. 5		116. 2940			F.
		N.	—1. 0532	—9. 6						F.
		N.	—1. 0625	—0. 3						F.
		N.	—1. 0644	+1. 6						P.
		Mean..	—1. 0628							
T. B. M. 238	219. 07	S	—2. 1197	+3. 5	2. 3		114. 1778			F.
		N.	—2. 1128	—3. 4						F.
		Mean..	—2. 1162							
T. B. M. 239	219. 99	S	—0. 2346	+6. 6	2. 3		113. 9498			F.
		N.	—0. 2232	—4. 8						F.
		N.	—C. 2263	—1. 7						P.
		Mean..	—0. 2280							
T. B. M. 240	221. 10	S	+2. 8857	+8. 1	2. 1		116. 8436			F.
		N.	+2. 8985	—4. 7						F.
		N.	+2. 8965	—4. 7						F.
		N.	+2. 8923	+1. 5						P.
		Mean..	+2. 8938							
U. S. P. B. M. 42	221. 76	S	+2. 5818	0. 0	0. 0	17. 8	119. 4254	+0. 1	119. 4255	F.
		N	+2. 5817	+0. 1						F.
		Mean..	+2. 5818							
*39 ft. mark of water-gauge at Grand Eddy, Mo.							116. 3140			
T. B. M. 241	222. 43	N.	—1. 5931	+0. 2	0. 1		117. 8325			P.
		S	—1. 5927	—0. 2						P.
		Mean..	—1. 5929							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
S.P.B.M.1							156.5368	+0.2	156.5370	
ero U.S. Engineer's gauge on anal, Keokuk, owa.		S	−4.7631	−4.2	2.8		151.7695			J.
		N	−4.7715	+4.2						F.
		N	−4.9131	(†)						F.
		Mean	−4.7673							
Canal" B.M. of Captain Stickney.		S	−0.0108	−1.8	1.4	1.4	156.5242			J.
		S	−0.0103	−2.3						J.
		N	−0.0189	+6.3						F.
		N	−0.0105	−2.1						F.
		Mean	−0.0126							
P.B.M.52 of Captain Mackenzie.	0.31	S	+1.5121	−4.9	1.8	1.8	158.0440			J.
		S	+1.5039	+3.3						J.
		N	+1.5016	+5.6						F.
		N	+1.5113	−4.1						F.
		Mean	+1.5072							
S.P.B.M.2	0.45	S	+0.2179	−3.3	1.8	1.8	156.7514	+0.2	156.7516	J.
		S	+0.2166	−2.0						J.
		N	+0.2066	+8.0						F.
		N	+0.2174	−2.8						F.
		Mean	+0.2146							
Zero of U.S. Signal Service gauge.		S	−5.3178	+9.5			151.4431			J.
		N	−5.2988	−9.5						F.
		Mean	−5.3083							
S.P.B.M.3	0.69	S	+4.6390	−1.0	0.4	1.8	161.3894	+0.2	161.3896	J.
		N	+4.6368	+1.2						F.
		S	+4.6382	−0.2						J.
		Mean	+4.6380							
B.M.1	2.05	S	−4.2591	+0.6	1.4		157.1309			J.
		N	−4.2547	−3.8						F.
		S	−4.2616	+3.1						J.
		Mean	−4.2585							
B.M.2	3.37	S	−0.5248	+4.3	1.5		156.6104			J.
		N	−0.5192	−1.3						F.
		S	−0.5176	−2.9						J.
		Mean	−0.5205							
S.P.B.M.4	5.35	S	+1.8158	−2.1	0.8	2.9	158.4241	+0.2	158.4243	J.
		N	+1.8117	+2.0						F.
		N	+1.8135	+0.2						F.
		Mean	+1.8137							
B.M.4	7.59	S	−2.7100	−0.2	0.1		155.7139			J.
		N	−2.7103	+0.1						F.
		Mean	−2.7102							
S.P.B.M.5	9.19	S	+2.2941	+0.5	0.4	2.9	158.0085	+0.2	158.0087	J.
		N	+2.2952	−0.6						F.
		Mean	+2.2946							
B.M.53 of Captain Mackenzie.		S	−0.3669	0.0	0.0	2.9	157.6416			J.
		N	−0.3669	0.0						F.
		Mean	−0.3669							

† Rejected.

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.
T. B. M. 266½	243.78	N	−1.0413	+0.1	0.1		115.4303		
		S	−1.0411	−0.1					
		Mean	−1.0412						
T. B. M. 267	244.50	N	−8.4535	+0.4	0.3		106.9772		
		S	−8.4527	−0.4					
		[illegible]	[illegible]						
T. B. M. 269	245.37	[illegible]	[illegible]	[illegible]	5.0		109.4933		
		[illegible]	[illegible]	[illegible]					
		[illegible]	[illegible]	[illegible]					
		Mean	[illegible]						
*U. S. P. B. M. 47			[illegible]	[illegible]	0.1	19.1	111.0030	+0.1	111.0031
			[illegible]	[illegible]					
		Mean	[illegible]						
T. B. M. 270	246.92	N	[illegible]	[illegible]	1.2		106.5806		
		N	[illegible]	[illegible]					
		N	[illegible]	[illegible]					
		Mean	[illegible]						
T. B. M. 271	248.26	N	[illegible]	[illegible]	0.4		108.6656		
		N	[illegible]	[illegible]					
		Mean	+2[illegible]						
U. S. P. B. M. 48	252.06	N	+1.[illegible]	−3.4	2.3	19.3	110.0316	+0.1	110.0317
		N	+1.[illegible]	+3.4					
		Mean	+1.3660						
T. B. M. 274	252.94	N	−3.4783	−1.9	1.3		106.5514		
		N	−3.4821	+1.9					
		Mean	−3.4802						
T. B. M. 275	253.90	N	−0.5678	+3.4	1.1		105.9870		
		N	−0.5628	−1.6					
		N	−0.5627	−1.7					
		Mean	−0.5644						
T. B. M. 276	255.06	N	+2.8794	−0.8	0.5		108.8656		
		N	+2.8778	+0.8					
		Mean	+2.8786						
U. S. P. B. M. 49	256.90	N	+1.3358	−0.4	0.3	19.4	110.2010	+0.1	110.2011
		N	+1.3349	+0.5					
		Mean	+1.3354						
T. B. M. 278	258.13	S	−3.7123	−0.5	0.4		106.4882		
		N	−3.7134	+0.6					
		Mean	−3.7128						
T. B. M. 283	261.63	S	+5.8008	+2.3	1.5		112.2913		
		N	+5.8054	−2.3					
		Mean	+5.8031						
T. B. M. 285	262.30	S	−0.0784	+2.3	1.1		112.2152		
		N	−0.0728	−3.3					
		N	−0.0771	+1.0					
		Mean	−0.0761						

***Results of precise leveling*—Continued.**

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M. 50	264.06	S	-1.9892	-0.4	0.3	19.5	110.2256	+0.1	110.2257	F.
		N	-1.9901	+0.5						P.
		Mean	-1.9896							
M. 287	265.17	S	-3.0334	-4.6	1.7		107.1876			F.
		N	-3.0386	+0.6						F.
		N	-3.0419	+3.9						P.
		Mean	-3.0380							
M. 289	266.54	S	-0.2684	+2.6	1.7		106.9218			F.
		N	-0.2632	-2.6						F.
		Mean	-0.2658							
M. 291	268.49	S	-1.8695	-5.9	4.0		105.0464			P.
		N	-1.8814	+6.0						P.
		Mean	-1.8754							
M. 293	270.00	S	-0.7045	-3.4	1.2		104.3385			F.
		N	-0.7108	+2.9						F.
		S	-0.7084	+0.5						F.
		Mean	-0.7079							
M. 295	270.16	S	+0.7342	-0.2	0.4		105.0725			F.
		N	+0.7349	-0.9						F.
		S	+0.7329	+1.1						F.
		Mean	+0.7340							
P. B. M. 51	270.79	S	+4.0609	+0.7	0.5	20.1	109.1341	0.0	109.1341	F.
		N	+4.0624	-0.8						F.
		Mean	+4.0616							
M. 298	271.64	S	+2.6249	-0.5	0.3		111.7585			F.
		N	+2.6240	+0.4						F.
		Mean	+2.6244							
M. 300	272.68	S	+1.7980	0.0	0.0		113.5565			F.
		N	+1.7981	-0.1						F.
		Mean	+1.7980							
M. 301	273.30	S	-1.8182	-0.1	0.1		111.7382			F.
		N	-1.8184	+0.1						F.
		Mean	-1.8183							
B. M. 302½	274.06	S	-1.4306	-1.2	0.8		110.3064			F.
		N	-1.4329	+1.1						F.
		Mean	-1.4318							
B. M. 303	274.79	S	-0.2885	-4.1	1.5		110.0138			F.
		N	-0.2930	+0.4						F.
		S	-0.2963	+3.7						F.
		Mean	-0.2926							
S. P. B. M. 52	275.49	S	+0.5587	+1.8	1.2	20.2	110.5743	+0.1	110.5744	F.
		N	+0.5623	-1.8						F.
		Mean	+0.5605							
B. M. 305	276.46	S	-2.6277	+2.8	1.9		107.9494			F.
		N	-2.6221	-2.8						F.
		Mean	-2.6249							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 26	52.16	S	+0.8658	−0.8	0.5	......	151.2596	......	....	J.
		N	+0.8643	+0.7	......	......	....	......	....	F.
		Mean..	+0.8650							
T. B. M. 27	53.72	S	+0.3691	+0.3	0.2	......	151.6290	......	....	J.
		N	+0.3697	−0.3	......	......	....	......	....	F.
		Mean..	+0.3694							
T. B. M. 28	56.47	S	−0.9717	+0.1	0.0	......	150.6574	......	....	J.
		N	−0.9716	0.0	......	......	....	......	....	F.
		Mean..	−0.9716							
T. B. M. 29	58.12	S	+0.0598	+1.0	0.7	......	150.7182	......	....	J.
		N	+0.0618	−1.0	......	......	....	......	....	F.
		Mean..	+0.0608							
U. S. P. B. M. 12	60.57	N	+0.9949	+5.5	1.5	5.7	151.7186	+0.1	151.7187	F.
		S	+0.9997	+0.7	......	......	....	......	....	J.
		S	+1.0059	−5.5	......	......	....	......	....	J.
		N	+1.0011	−0.7	......	......	....	......	....	F.
		Mean..	+1.0004							
*P. B. M. 57 of Capt. Mackenzie.	60.55	S	−0.1712	......	......	......	151.5474	......	....	J.
*P. B. M. 59 of Capt. Mackenzie.	60.57	N	−0.1725	......	......	......	151.5461	......	....	F.
T. B. M. 31	62.04	S	−1.0519	+0.8	0.5	......	150.6675	......	....	J.
		N	−1.0503	−0.8	......	......	....	......	....	F.
		Mean..	−1.0511							
T. B. M. 32	63.81	S	+0.4306	+0.6	0.4	......	151.0987	......	....	J.
		N	+0.4317	−0.5	......	......	....	......	....	F.
		Mean..	+0.4312							
T. B. M. 33	65.82	S	−1.0042	+0.4	0.3	5.7	150.0949	......	....	J.
		N	−1.0033	−0.5	......	......	....	......	....	F.
		Mean..	−1.0038							
U. S. P. B. M. 13	67.18	S	+1.8197	−0.1	0.1	......	151.9145	+0.1	151.9146	J.
		N	+1.8195	+0.1	......	......	....	......	....	F.
		Mean..	+1.8196							
T. B. M. 35	70.76	S	−2.3169	−0.4	0.3	......	149.5972	......	....	J.
		N	−2.3177	+0.4	......	......	....	......	....	F.
		Mean..	−2.3173							
U. S. P. B. M. 14	71.84	S	+1.2115	−2.3	1.5	5.9	150.8064	+0.1	150.8065	J.
		N	+1.2069	+2.3	......	......	....	......	....	F.
		Mean..	+1.2092							
T. B. M. 37	74.12	S	−1.5722	+2.8	1.9	......	149.2370	......	....	J.
		N	−1.5666	−2.8	......	......	....	......	....	F.
		Mean..	−1.5694							
T. B. M. 38	75.90	S	−0.7520	−2.3	1.5	......	148.4827	......	....	J.
		N	−0.7566	+2.3	......	......	....	......	....	F.
		Mean..	−0.7543							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 54	97.53	S	−0.5377	+0.9	0.6	......	147.4344	......	....	J.
		N	−0.5350	−0.9	......	......	....	......	....	F.
		Mean ..	−0.5368							
T. B. M. 56	100.73	S	−0.9690	−0.4	0.8	......	146.4650	... ..	....	J.
		N	−0.9698	+0.4	......	......	....	......	....	F.
		Mean ..	−0.9694							
U. S. P. B. M. 18 ...	102.04	S	+0.9168	−1.8	1.2	7.4	147.3800	+0.1	147.3801	J.
		N	+0.9131	+1.9	......	......	....	......	....	F.
		Mean ..	+0.9150							
T. B. M. 59	104.69	S	−0.0033	−1.7	1.1	......	147.3750	......	....	J.
		N	−0.0067	+1.7	......	......	....	......	....	F.
		Mean ..	−0.0050							
T. B. M. 60	106.33	S	+0.1227	(†)	0.4	......	147.5083	......	....	J.
		N	+0.1339	−0.6	......	......	....	......	....	F.
		S	+0.1322	+1.1	......	......	....	......	....	J.
		N	+0.1339	−0.6	......	......	....	......	....	F.
		Mean ..	+0.1333							
T. B. M. 63	108.41	S	−0.0055	+3.3	2.2	......	147.5061	......	....	J.
		N	+0.0012	−3.4	......	......	....	......	....	F.
		Mean ..	−0.0022							
T. B. M. 64	109.73	S	−0.0031	+0.4	1.2	......	147.5034	......	....	J.
		N	+0.0032	−5.9	......	......	....	......	....	F.
		S	−0.0042	+1.5	......	......	....	.. ..	....	Sn.
		N	−0.0072	+4.5	......	......	....	......	....	R.
		N	−0.0020	−0.7	......	......	....	......	....	F.
		Mean ..	−0.0027							
*U. S. P. B. M. 19 ..	110.65	S	+4.2446	+1.6	1.1	7.9	151.7496	+0.1	151.7497	J.
		N	+4.2479	−1.7	......	......	....	......	....	F.
		Mean ..	+4.2462							
T. B. M. 65	110.46	S	+0.6272	+1.0	0.6	......	148.1316	......	....	J.
		N	+0.6291	−0.9	......	......	....	......	....	F.
		Mean ..	+0.6282							
T. B. M. 66	112.86	S	−2.0781	+0.1	0.1	......	146.0536	......	....	J.
		N	−2.0779	−0.1	......	......	....	......	....	F.
		Mean ..	−2.0780							
T. B. M. 67	115.61	S	+4.1836	−1.1	0.7	......	150.2361	......	....	J.
		N	+4.1814	+1.1	......	......	....	......	....	F.
		Mean ..	+4.1825							
*U. S. P. B. M. 20 ..	115.73	S	+0.3403	−0.3	0.2	7.9	150.5761	+0.1	150.5762	J.
		N	+0.3396	+0.4	......	......	....	......	....	F.
		Mean ..	+0.3400							
T. B. M. 68	116.38	S	−0.8351	−1.4	0.9	......	149.3096	......	....	J.
		N	−0.8379	+1.4	......	......	....	......	....	F.
		Mean ..	−0.8365							

† Rejected.

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO GRAFTON ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 70	119.02	S	−4.1408	−4.8	1.8		145.2540			J.
		N	−4.1502	+4.6						F.
		S	−4.1458	+0.2						J.
		Mean	−4.1456							
T. B. M. 73	122.29	S	+1.3659	−0.9	0.6		146.6190			J.
		N	+1.3640	+1.0						F.
		Mean	+1.3650							
*U. S. P. B. M. 21	122.60	S	−1.4127	−0.9	0.6	8.2	145.2054	+0.1	145.2055	J.
		N	−1.4145	+0.9						F.
		Mean	−1.4136							
T. B. M. 75	126.51	S	−1.2050	+1.0	0.7		145.4150			J.
		N	−1.2030	−1.0						F.
		Mean	−1.2040							
T. B. M. 78	129.02	S	+2.6030	−0.8	0.6		148.0172			J.
		N	+2.6013	+0.9						F.
		Mean	+2.6022							
*U. S. P. B. M. 22	129.04	S	+0.9630			8.2	148.9802	+0.1	148.9803	J.
T. B. M. 79	130.26	S	+0.2989	−0.7	0.5		148.3154			J.
		N	+0.2974	+0.8						F.
		Mean	+0.2982							
U. S. P. B. M. 23	132.30	S	+0.6582	−1.8	1.2	8.3	148.9718	+0.1	148.9719	J.
		N	+0.6547	+1.7						F.
		Mean	+0.6564							
*P. B. M. 61, Mackenzie.	131.39	S	−1.9095	+1.0	0.7	8.4	147.0633			J.
		N	+1.9075	−1.0						F.
		Mean	−1.9085							
*H. W. 1851, at Louisiana, Mo.	131.86	N	−2.8545				146.1173			F.
*H. W. 1880, at Louisiana, Mo.	132.26	N	−4.3271				144.6447			F.
*H. W. 1881 (April), Louisiana, Mo.	132.26	N	−4.0681				144,9037			F.
U. S. P. B. M. 24	133.74	S	−0.2803	−0.9	0.6	8.4	148.6906	+0.1	148.6907	J.
		N	−0.2821	+0.9						F.
		Mean	−0.2812							
*H. W. 1881 (April) Louisiana, Mo.	132.42	N	−4.0285				144.9433			F.
*H. W. 1880, Louisiana, Mo.	132.42	N	−4.3252				144.6466			F.
*H. W., April 26, 1881, Louisiana, Mo.		N	−4.0678				144.6228			F.
*Zero of gauge on bridge at Louisiana, Mo.	134.05		−9.2708	−11.4	5.7		139.4312			F.
			−9.2537	+5.7						J.
		Mean	−9.2594							
T. B. M. 82	136.00	S	−3.9939	+0.3	0.2		144.6970			J.
		N	−3.9934	−0.2						F.
		Mean	−3.9936							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*
T. B. M. 308	278. 04	S	+0. 8635	+0. 5	0. 3	......	108. 8134	......	....
		N	+0. 8644	−0. 4	......	......	....	......	....
		Mean ..	+0. 8640						
T. B. M. 309	279. 11	S	+0. 2051	+3. 6	1. 3	......	109. 0221	......	....
		N	+0. 2117	−3. 0	......	......	....	......	....
		N	+0. 2094	−0. 7	......	......	....	......	....
		Mean ..	[illegible]						
T. B. M. 311	279. 80	N	[illegible]	[illegible]	0. 0	......	110. 3192	......	....
		S	[illegible]	[illegible]	......	......	....	......	....
		Mean ..	+1. [illegible]						
T. B. M. 314	281. 89	S	−1[illegible]	[illegible]	1. 1	......	108. 7160	......	....
		N	−1. [illegible]	[illegible]	......	......	....	......	....
		Mean ..	−1. 6032						
U. S. P. B. M. 53 ...	285. 34	N	+0. 0515	−3. 5	2. 3	20. 5	108. 7640	0. 0	108. 7640
		S	+0. 0445	+3. 5	......	......	....	......	....
		Mean ..	+0, 0480						
T. B. M. 318	285. 61	S	+2. 5515	−0. 2	0. 1	......	111. 3153	......	....
		N	+2. 5511	+0. 2	......	......	....	......	....
		Mean ..	+2. 5513						
T. B. M. 320	286. 88	S	−0. 7217	−0. 5	0. 4	......	110. 5931	......	....
		N	−0. 7228	+0. 6	......	......	....	......	....
		Mean ..	−0. 7222						
T. B. M. 321	287. 74	S	+0. 0083	+2. 8	1. 0	......	110. 6042	......	....
		N	+0. 0128	−1. 7	......	......	....	......	....
		S	+0. 0123	−1. 2	......	......	....	......	....
		Mean ..	+0. 0111						
U. S. P. B. M. 54 ...	288. 51	S	+1. 1415	+3. 7	1. 2	20. 5	111. 7494	+0. 1	111. 7495
		N	+1. 1464	−1. 2	......	......	....	......	....
		N	+1. 1477	−2. 5	......	......	....	......	....
		Mean ..	+1. 1452						
*H. W. mark July, 1844.	....	....	+0. 2650	......	......	......	112. 0149	......	....
			+0. 2660	......	......	......	....	......	....
		Mean ..	+0. 2655						
U. S. P. B. M. 55 ...	289. 41	S	+3. 0233	+0. 2	0. 1	20. 5	114. 7729	+0. 1	114. 7730
		N	+3. 0237	−0. 2	......	......	....	......	....
		Mean ..	+3. 0235						
U. S. P. B. M. 56 ...	289. 71	S	−7. 6481	−0. 1	0. 1	20. 5	107. 1247	0. 0	107. 1247
		N	−7. 6484	+0. 2	......	......	....	......	....
		Mean ..	−7. 6482						
T. B. M. 324	291. 22	S	+2. 0458	+0. 6	0. 4	......	109. 1711	......	....
		N	+2. 0471	−0. 7	......	......	....	......	....
		Mean ..	+2. 0464						
T. B. M. 326	292. 92	N	−0. 5109	+0. 6	0. 4	......	108. 6608	......	....
		S	−0. 5097	−0. 6	......	......	....	......	....
		Mean ..	−0. 5103						

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 328	294.14	N	−0.4683	−0.8	0.5		108.1917			F.
		S	−0.4699	+0.8						F.
		Mean	−0.4691							
U. S. P. B. M. 57	297.49	S	+2.7111	+2.7	1.8	20.6	110.9055	+0.1	110.9056	F.
		N	+2.7166	−2.8						F.
		Mean	+2.7138							
T. B. M. 331½	297.86	N	−8.6692	+0.1	0.1		102.2364			F.
		S	−8.6690	−0.1						F.
		Mean	−8.6691							
*6 feet mark of upper gauge at Gray's Point, Mo.			−1.8066				100.4316			F.
			−1.8031							F.
		Mean	−1.8048							
T. B. M. 332	299.05	N	−1.7321	−5.0	1.9		100.4993			F.
		S	−1.7417	+4.6						F.
		S	−1.7376	+0.5						F.
		Mean	−1.7371							
U. S. B. M. 74 (Old B. M.)	299.37	S	+2.0451	+0.4	0.3	20.7	102.5448	0.0	102.5448	F.
		N	+2.0459	−0.4						F.
		Mean	+2.0455							
*H. W. mark, July, 1844, at Gray's Point, Mo.			+8.7797				111.3240			F.
			+8.7788							F.
		Mean	+8.7792							
T. B. M. 334	300.53	S	+5.2311	−0.7	0.4		107.7752			F.
		N	+5.2298	+0.6						F.
		Mean	+5.2304							
T. B. M. 335	301.66	S	+0.1470	−0.6	0.4		107.9216			F.
		N	+0.1458	+0.6						F.
		Mean	+0.1464							
T. B. M. 338	304.16	S	+1.7995	+1.7	1.1		109.7228			F.
		N	+1.8029	−1.7						F.
		Mean	+1.8012							
U. S. P. B. M. 58	305.24	S	+0.9547	−0.3	0.2	20.8	110.6772	+0.1	110.6773	F.
		N	+0.9542	+0.2						F.
		Mean	+0.9544							
T. B. M. 340	306.18	N	−2.4323	+1.1	0.7		108.2460			F.
		S	−2.4301	−1.1						F.
		Mean	−2.4312							
T. B. M. 342	307.32	N	−0.3806	−1.1	1.1		107.8643			F.
		S	−0.3850	+3.3						F.
		N	−0.3795	−2.2						F.
		Mean	−0.3817							
T. B. M. 343	308.10	S	−3.4597	−0.2	0.1		104.4044			F.
		N	−3.4601	+0.2						F
		Mean	−3.4599							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	v.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 86	138.59	S	+2.1569	—1.6	1.1		147.8523			J.
		N	+2.1537	+1.6						F.
		Mean	+2.1553							
U. S. P. B. M. 25	140.02	S	—0.5688	—0.8	0.6		147.2827	+0.1	147.2828	J.
		N	—0.5705	+0.9						F.
		Mean	— 0.5696							
T. B. M. 87	141.07	S	—1.3650	+0.4	0.2		145.9181			J.
		N	—1.3643	—0.3						F.
		Mean	—1.3646							
T. B. M. 88	142.29	S	+0.0446	—5.0	1.2		145.9577			J.
		N	+0.0376	+2.0						F.
		S	+0.0394	+0.2						J.
		N	+0.0366	+3.0						F.
		Mean	+0.0396							
*U. S. P. B. M. 26	143.64	S	+0.6903	—0.9	0.6	8.6	146.6471	+0.1	146.6472	J.
		N	+0.6884	+1.0						F.
		Mean	+0.6894							
T. B. M. 89	144.08	S	—2.3480	—1.6	1.1		143.6081			J.
		N	—2.3512	+1.6						F.
		Mean	—2.3496							
T. B. M. 91	145.68	S	—0.6939	—1.1	0.7		142.9131			J.
		N	—0.6960	+1.0						F.
		Mean	—0.6950							
T. B. M. 92	147.02	S	+0.0963	—1.8	1.2		143.0076			J.
		N	+0.0927	+1.8						F.
		Mean	+0.0945							
T. B. M. 94	147.05	S	+4.4392	—2.8	0.7		147.4445			J.
		N	+4.4346	+2.3						F.
		S	+4.4360	+0.9						J.
		N	+4.4379	—1.0						F.
		Mean	+4.4369							
*U. S. P. B. M. 27	148.07	S	+0.5737	0.0	0.0	8.8	148.0182	+0.1	148.0183	J.
		N	+0.5737	0.0						F.
		Mean	+0.5737							
T. B. M. 95	148.93	S	—1.0499	+0.1	0.1		146.3947			J.
		N	—1.0497	—0.1						F.
		Mean	—1.0498							
*U. S. P. B. M. 28	149.07	S	+0.1658	+0.4	0.3	8.8	146.5609	+0.1	146.5610	J.
		N	+0.1666	—0.4						F.
		Mean	+0.1662							
*H. W. 1876, Clarksville, Mo.	149.15	N	—3.4625				142.9322			F.
*H. W. 1851, Clarksville, Mo.	149.13	S	—1.5284				144.8663			J.
Rod station 1, Clarksville, Mo.	148.98	S	—3.7384	—0.4	0.8		142.6550			J.
		N	—3.7392	+0.4						F.
		Mean	—3.7388							

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
Rod station 2, Island 462.	149.58		+0.0771	—0.5	0.3		142.7325			J.
			+0.0762	+0.4						F.
		Mean..	+0.0766							
Rod station 3	149.80	S	+0.0777	—0.5	0.3		142.8097			J.
		N	+0.0768	+0.4						F.
		Mean..	+0.0772							
Rod station 4	150.46		—0.7212	+1.1	0.7		142.0896			J.
			—0.7190	—1.1						F.
		Mean..	—0.7201							
Rod station 5	150.73		+0.8106	+1.0	0.7		142.9012			J.
			+0.8126	—1.0						F.
		Mean..	+0.8116							
*U. S. P. B. M. 29	150.83	S	—0.0161	—0.7	0.5	8.8	142.8844	+0.0	142.8844	J.
		N	—0.0175	+0.7						F.
		Mean..	—0.0168							
T. B. M. 97	152.75	S	—0.2629	+0.9	0.6		142.6392			J.
		N	—0.2612	—0.8						F.
		Mean..	—0.2620							
T. B. M. 99	155.15	S	+ 1.2087	0.0	0.0		143.8479			J.
		N	+ 1.2087	0.0						F.
		Mean..	+ 1.2087							
*U. S. P. B. M. 30	155.60	S	— 0.9795	—0.3	0.2	8.8	142.8681	0.0	142.8681	J.
		N	— 0.9801	+0.3						F.
		Mean..	— 0.9798							
T. B. M. 101	157.80	S	— 2.2617	—2.4	1.6		141.5838			J.
		N	— 2.2665	+2.4						F.
		Mean..	— 2.2641							
T. B. M. 102	159.76	S	+ 1.2668	—0.8	0.6		142.8498			J.
		N	+ 1.2651	+0.9						F.
		Mean..	+ 1.2660							
U. S. P. B. M. 31	161.18	S	— 0.8392	—0.4	0.2	9.0	142.0102	0.0	142.0102	J.
		N	— 0.8399	+0.3						F.
		Mean..	— 0.8396							
T. B. M. 104	162.18	S	— 0.9919	—0.9	0.6		141.0174			J.
		N	— 0.9936	+0.8						F.
		Mean..	— 0.9928							
T. B. M. 106	165.62	S	+ 0.3240	+2.1	1.4		141.3435			J.
		N	+ 0.3282	—2.1						F.
		Mean..	+ 0.3261							
U. S. P. B. M. 32	165.96	S	+ 7.2578	—1.4	0.9	9.2	148.5999	+0.1	148.6000	J.
		N	+ 7.2551	+1.3						F.
		Mean..	+ 7.2564							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 385	338.13	S	+0.6551	+1.1	0.7		103.0641			P.
		N	+0.6572	−1.0						P.
		Mean	+0.6562							
T. B. M. 387	339.48	S	−0.2534	+2.4	1.6		102.8131			F.
		N	−0.2486	−2.4						F.
		Mean	−0.2510							
T. B. M. 388	340.51	S	−1.2929	+3.8	1.6		101.5240			F.
		N	−1.2849	−4.2						F.
		N	−1.2896	+0.5						F.
		Mean	−1.2891							
*T. B. M. 388½	340.97	S	+1.0554	+0.7	0.5		102.5801			F.
		N	+1.0568	−0.7						Sn.
		Mean	+1.0561							
*U. S. P. B. M. 66	341.46	N	−1.1030	+0.6	0.4	21.5	101.4777	0.0	101.4777	Sn.
		S	−1.1019	−0.5						Sn.
		Mean	−1.1024							
T. B. M. 389	341.94	S	−0.0876	+2.8	1.1		101.4392			F.
		N	−0.0822	−2.6						P.
		N	−0.0845	−0.3						F.
		Mean	−0.0848							
T. B. M. 391	343.07	S	−0.7814	−8.4	2.9		100.6494			B.
		N	−0.7952	+5.4						P.
		S	−0.7928	+3.0						B.
		Mean	−0.7898							
B. M. 55 (old B. M.)	344.64	S	+1.2974	−1.2	0.8		101.9456			B.
		N	+1.2950	+1.2						P.
		Mean	+1.2962							
U. S. P. B. M. 2, Cairo, Ill.	344.88	S	+1.4601	−1.0	0.7	21.7	103.4047	0.0	103.4047	B.
		S	+1.4581	+1.0						B.
		Mean	+1.4591							
U. S. P. B. M. 1, Cairo, Ill.	345.23	S	−0.4015	−2.7	1.8	21.8	103.0005	0.0	103.0005	B.
		S	−0.4068	+2.6						B.
		Mean	−0.4042							
U. S. P. B. M. 3, Cairo, Ill.	345.66	S	+2.8234	+0.7	0.5	21.8	105.8246	0.0	105.8246	F.
		N	+2.8248	−0.7						F.
		Mean	+2.8241							
45-foot mark of water gauge, Cairo, Ill.		S	−3.4546	+0.4	0.3		102.3704			F.
		N	−3.4538	−0.4						F.
		Mean	−3.4542							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 1							156.5368	+0.2	156.5370	
*Zero U. S. Engineer's gauge on canal, Keokuk, Iowa.		S	−4.7631	−4.2	2.8		151.7695			J.
		N	−4.7715	+4.2						F.
		N	−4.9131	(†)						F.
		Mean	−4.7673							
*"Canal" B. M. of Captain Stickney.		S	−0.0108	−1.8	1.4	1.4	156.5242			J.
		S	−0.0103	−2.3						J.
		N	−0.0189	+6.3						F.
		N	−0.0105	−2.1						F.
		Mean	−0.0126							
*P. B. M. 52 of Captain Mackenzie.	0.31	S	+1.5121	−4.9	1.8	1.8	158.0440			J.
		S	+1.5039	+3.3						J.
		N	+1.5016	+5.6						F.
		N	+1.5113	−4.1						F.
		Mean	+1.5072							
U. S. P. B. M. 2	0.45	S	+0.2179	−3.3	1.8	1.8	156.7514	+0.2	156.7516	J.
		S	+0.2166	−2.0						J.
		N	+0.2066	+8.0						F.
		N	+0.2174	−2.8						F.
		Mean	+0.2146							
*Zero of U. S. Signal Service gauge.		S	−5.3178	+9.5			151.4431			J.
		N	−5.2988	−9.5						F.
		Mean	−5.3083							
C. S. P. B. M. 3	0.60	S	+4.6390	−1.0	0.4	1.8	161.3894	+0.2	161.3896	J.
		N	+4.6368	+1.2						F.
		S	+4.6382	−0.2						J.
		Mean	+4.6380							
T. B. M. 1	2.05	S	−4.2591	+0.6	1.4		157.1309			J.
		N	−4.2547	−3.8						F.
		S	−4.2616	+3.1						J.
		Mean	−4.2585							
T. B. M. 2	3.37	S	−0.5248	+4.3	1.5		156.6104			J.
		N	−0.5192	−1.3						F.
		S	−0.5176	−2.9						J.
		Mean	−0.5205							
U. S. P. B. M. 4	5.35	S	+1.8158	−2.1	0.8	2.9	158.4241	+0.2	158.4243	J.
		N	+1.8117	+2.0						F.
		N	+1.8135	+0.2						F.
		Mean	+1.8137							
T. B. M. 4	7.50	S	−2.7100	−0.2	0.1		155.7139			J.
		N	−2.7103	+0.1						F.
		Mean	−2.7102							
U. S. P. B. M. 5	9.19	S	+2.2941	+0.5	0.4	2.9	158.0085	+0.2	158.0087	J.
		N	+2.2952	−0.6						F.
		Mean	+2.2946							
*P. B. M. 53 of Captain Mackenzie.		S	−0.3669	0.0	0.0	2.9	157.6416			J.
		N	−0.3669	0.0						F.
		Mean	−0.3669							

† Rejected.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 6	10.37	S	−2.7041	−0.1	0.0		155.3043			J.
		N	−2.7042	0.0						F.
		Mean	−2.7042							
T. B. M. 8	13.74	S	+0.0407	+2.5	1.7		155.3475			J.
		N	+0.0457	−2.5						F.
		Mean	+0.0432							
T. B. M. 9	15.68	S	−0.1265	−3.0	2.0	3.9	155.2180			J.
		N	−0.1325	+3.0						F.
		Mean	−0.1295							
T. B. M. 10	16.77	S	−0.3650	+0.4	0.2		154.8534			J.
		N	−0.3643	−0.3						F.
		Mean	−0.3646							
P. B. M. 54 of Captain Mackenzie.	19.45	S	−0.8667	−1.3	0.9	4.0	153.9854			J.
		N	−0.8694	+1.4						F.
		Mean	−0.8680							
* H. W. Apr., 1881, at Gregory Ldg.	19.80	N	+1.1620				155.1474			F.
* U. S. P. B. M. 6	19.57	S	+0.7836	−0.2	0.1	4.0	154.7688	+0.2	154.7690	F.
		N	+0.7832	+0.2						F.
		Mean	+0.7834							
T. B. M. 11	21.70	S	+0.1007	−2.6	1.7		154.0835			J.
		N	+0.0955	+2.6						F.
		Mean	+0.0981							
T. B. M. 12	24.19	S	−0.5573	+1.9	1.3		153.5243			J.
		N	−0.5611	−1.9						F.
		Mean	−0.5592							
T. B. M. 13	26.50	S	+0.0472	+0.2	0.1		153.5717			J.
		N	+0.0476	−0.2						F.
		Mean	+0.0474							
U. S. P. B. M. 7	28.13	S	+3.6614	+1.6	1.1	4.7	157.2347	+0.2	157.2349	J.
		N	+3.6646	−1.6						F.
		Mean	+3.6630							
T. B. M. 15	30.94	S	−0.3452	+2.0	1.3		156.8915			J.
		N	−0.3412	−2.0						F.
		Mean	−0.3432							
T. B. M. 16	32.21	S	−3.9274	0.0	0.0		152.9641			J.
		N	−3.9274	0.0						F.
		Mean	−3.9274							
T. B. M. 17	33.86	S	+0.8602	+0.2	0.1		153.8245			J.
		N	+0.8606	−0.2						F.
		Mean	+0.8604							
* H. W. 1844, 1½ miles above Canton, Mo.		S	−0.3000				153.5245			J.
* H. W. 1851, 1½ miles above Canton, Mo.		S	+0.3700				154.1945			J.

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
. M. 18	36.30	S	−0.8609	+2.4	1.3		152.9660			J.
		N	−0.8530	−5.5						F.
		S	−0.8595	+1.0						J.
		N	−0.8607	+2.2						F.
		Mean	−0.8585							
S. P. B. M. 8	37.34	S	+3.8201	−0.7	0.5	5.1	156.7854	+0.2	156.7856	J.
		N	+3.8187	+0.7						F.
		Mean	+3.8194							
S. P. B. M. 9	37.52	S	−0.2009	+0.2	0.1	5.1	156.5847	+0.2	156.5849	J.
		N	−0.2005	−0.2						F.
		Mean	−0.2007							
B. M. 19	38.37	S	−0.1998	−0.4	0.3		152.7658			J.
		N	−0.2006	+0.4						F.
		Mean	−0.2002							
B. M. 20	40.67	S	+0.3848	+0.1	0.1	5.0	153.1507			J.
		N	+0.3850	−0.1						F.
		Mean	+0.3849							
B. M. 21	42.46	S	−0.6062	+0.7	0.5		152.5452			J.
		N	−0.6048	−0.7						F.
		Mean	−0.6055							
S. P. B. M. 10	44.96	S	+1.0656	+1.1	0.7	5.1	153.6119	+0.1	153.6120	J.
		N	+1.0678	−1.1						F.
		Mean	+1.0667							
B. M. 56 of Captain Mackenzie.	46.88	N	−1.4532	+1.8	1.2		152.1605			F.
		S	−1.4496	−1.8						J.
		Mean	−1.4514							
U. S. P. B. M. 11	46.98	S	+1.4188	−0.2	0.1	5.2	153.5791	+0.1	153.5792	F.
		S	+1.4184	+0.2						F.
		Mean	+1.4186							
H. W. April, 1881, at La Grange, Mo.			+0.1072	−0.2	0.2		152.2675			F.
			+0.1067	+0.3						J.
		Mean	+0.1070							
H. W. 1851, (?) at La Grange, Mo.			+1.5075	−4.1			153.6639			F.
			+1.4903	+13.1						J.
			+1.5123	−8.9						J.
		Mean	+1.5034							
B. M. 23	47.89	S	−0.0617	−1.8	1.0		152.0970			J.
		N	−0.0678	+4.3						F.
		S	−0.0612	−2.3						J.
		N	−0.0632	−0.3						F.
		Mean	−0.0635							
B. M. 25	50.14	S	−1.7030	+0.6	0.6		150.3946			J.
		N	−1.7018	−0.6						F.
		S	−1.7046	+2.2						J.
		N	−1.7001	−2.3						F.
		Mean	−1.7024							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Kw.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 26	52.16	S	+0.8658	−0.8	0.5		151.2596			J.
		N	+0.8643	+0.7						F.
		Mean	+0.8650							
T. B. M. 27	53.72	S	+0.3691	+0.3	0.2		151.6290			J.
		N	+0.3697	−0.3						F.
		Mean	+0.3694							
T. B. M. 28	56.47	S	−0.9717	+0.1	0.0		150.6574			J.
		N	−0.9716	0.0						F.
		Mean	−0.9716							
T. B. M. 29	58.12	S	+0.0598	+1.0	0.7		150.7182			J.
		N	+0.0618	−1.0						F.
		Mean	+0.0608							
U. S. P. B. M. 12	60.57	N	+0.9949	+5.5	1.5	5.7	151.7186	+0.1	151.7187	F.
		S	+0.9997	+0.7						J.
		S	+1.0059	−5.5						J.
		N	+1.0011	−0.7						F.
		Mean	+1.0004							
*P. B. M. 57 of Capt. Mackenzie.	60.55	S	−0.1712				151.5474			J.
*P. B. M. 59 of Capt. Mackenzie.	60.57	N	−0.1725				151.5461			F.
T. B. M. 31	62.04	S	−1.0519	+0.8	0.5		150.6675			J.
		N	−1.0503	−0.8						F.
		Mean	−1.0511							
T. B. M. 32	63.81	S	+0.4306	+0.6	0.4		151.0987			J.
		N	+0.4317	−0.5						F.
		Mean	+0.4312							
T. B. M. 33	65.82	S	−1.0042	+0.4	0.3	5.7	150.0949			J.
		N	−1.0033	−0.5						F.
		Mean	−1.0038							
U. S. P. B. M. 13	67.18	S	+1.8197	−0.1	0.1		151.9145	+0.1	151.9146	J.
		N	+1.8195	+0.1						F.
		Mean	+1.8196							
T. B. M. 35	70.76	S	−2.3169	−0.4	0.3		149.5972			J.
		N	−2.3177	+0.4						F.
		Mean	−2.3173							
U. S. P. B. M. 14	71.84	S	+1.2115	−2.3	1.5	5.9	150.8064	+0.1	150.8065	J.
		N	+1.2069	+2.3						F.
		Mean	+1.2092							
T. B. M. 37	74.12	S	−1.5722	+2.8	1.9		149.2370			J.
		N	−1.5666	−2.8						F.
		Mean	−1.5694							
T. B. M. 38	75.90	S	−0.7520	−2.3	1.5		148.4827			J.
		N	−0.7566	+2.3						F.
		Mean	−0.7543							

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*m.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 39	77.30	S	+0.0094	0.0	0.0		148.4921			J.
		N	+0.0095	—0.1						F.
		Mean	+0.0094							
T. B. M. 40	79.49	S	+0.2576	—3.4	2.2		148.7463			J.
		N	+0.2509	+3.3						F.
		Mean	+0.2542							
U. S. P. B. M. 15	80.93	S	+1.0065	—2.1	1.4	6.9	149.7507	+0.1	149.7508	J.
		N	+1.0023	+2.1						F.
		Mean	+1.0044							
T. B. M. 44	84.18	S	—0.2368	+0.2	0.1		149.5141			J.
		N	—0.2365	—0.1						F.
		Mean	—0.2366							
T. B. M. 47	86.95	S	—0.7815	+1.3	0.9		148.7339			J.
		N	—0.7788	—1.4						F.
		Mean	—0.7802							
*U. S. P. B. M. 16	88.97	S	+6.5296	+1.4	0.9	7.0	155.2649	+0.2	155.2651	J.
		N	+6.5323	—1.3						F.
		Mean	+6.5310							
T. B. M. 48	88.90	S	+4.0618	+1.1	0.7		152.7968			J.
		N	+4.0640	—1.1						F.
		Mean	+4.0629							
*P. B. M. 58 of Capt. Mackenzie.	88.90	S	+0.0037	—0.1	0.1	7.0	152.8004			J.
		N	+0.0034	+0.2						F.
		Mean	+0.0036							
*H. W. 1881, at Hannibal Bridge.	88.90		—3.8321				148.9647			F.
*Zero of upper gauge at Hannibal Bridge.	89.13		—9.6481				143.1487			F.
*Zero of gauge on draw pier of Hannibal Bridge.	89.13		—9.6261				143.1707			F.
T. B. M. 49	90.86	S	—4.4287	+2.1	1.0		148.3660			J.
		N	—4.4338	+3.0						F.
		S	—4.4299	—0.9						J.
		Mean	—4.4308							
*H. W., 1851, at Hannibal, Mo.	90.20	S	+1.3548	+2.8	1.9		149.7236			J.
		N	+1.3605	—2.9						F.
		Mean	+1.3576							
*H. W., 1881, at Hannibal, Mo.	90.25		+0.5584				148.9244			J.
U. S. P. B. M. 17	92.51	S	—0.5664	+1.2	0.8	7.1	147.8008	+0.1	147.8009	J.
		N	—0.5640	—1.2						F.
		Mean	—0.5652							
T. B. M. 52	94.31	S	+0.1685	+1.9	1.3		147.9712			J.
		N	+0.1724	—2.0						F.
		Mean	+0.1704							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
T. B. M. 54	97.53	S	−0.5377	+0.9	0.6		147.4344			J.
		N	−0.5359	−0.9						F.
		Mean	−0.5368							
T. B. M. 56	100.73	S	−0.9690	−0.4	0.3		146.4650			J.
		N	−0.9698	+0.4						F.
		Mean	[illegible]							
U. S. P. B. M. 18	102.04	S	[illegible]	[illegible]	[illegible].2	7.4	147.3800	+0.1	147.3801	J.
		N	[illegible]	[illegible]						F.
		Mean	+0.9150							
T. B. M. 59	104.69	S	−0.0033	−1.7	1.1		147.3750			J.
		N	−0.0067	+1.7						F.
		Mean	−0.0050							
T. B. M. 60	106.33	S	+0.1227	(†)	0.4		147.5083			J.
		N	+0.1339	−0.6						F.
		S	+0.1322	+1.1						J.
		N	+0.1339	−0.6						F.
		Mean	+0.1333							
T. B. M. 63	108.41	S	−0.0055	+3.3	2.2		147.5061			J.
		N	+0.0012	−3.4						F.
		Mean	−0.0022							
T. B. M. 64	109.73	S	−0.0031	+0.4	1.2		147.5034			J.
		N	+0.0032	−5.9						F.
		S	−0.0042	+1.5						Sn.
		N	−0.0072	+4.5						R.
		N	−0.0020	−0.7						F.
		Mean	−0.0027							
*U. S. P. B. M. 19	110.65	S	+4.2446	+1.6	1.1	7.9	151.7496	+0.1	151.7497	J.
		N	+4.2479	−1.7						F.
		Mean	+4.2462							
T. B. M. 65	110 46	S	+0.6272	+1.0	0.6		148.1316			J.
		N	+0.6291	−0.9						F.
		Mean	+0.6282							
T. B. M. 66	112.86	S	−2.0781	+0.1	0.1		146.0536			J.
		N	−2.0779	−0.1						F.
		Mean	−2.0780							
T. B. M. 67	115.61	S	+4.1836	−1.1	0.7		150.2361			J.
		N	+4.1814	+1.1						F.
		Mean	+4.1825							
*U. S. P. B. M. 20	115.73	S	+0.3403	−0.3	0.2	7.9	150.5761	+0.1	150.5762	J.
		N	+0.3396	+0.4						F.
		Mean	+0.3400							
T. B. M. 68	116.38	S	−0.8351	−1.4	0.9		149.3096			J.
		N	−0.8379	+1.4						F.
		Mean	−0.8365							

† Rejected.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 70	119.02	S	—4.1408	—4.8	1.8	......	145.2540	......	....	J.
		N.......	—4.1502	+4.6	......	......	....	......	....	F.
		S	—4.1458	+0.2	......	......	....	......	....	J.
		Mean ..	—4.1456							
T. B. M. 73	122.29	S	+1.3659	—0.9	0.6	......	146.6190	......	....	J.
		N.......	+1.3640	+1.0	......	......	....	......	....	F.
		Mean ..	+1.3650							
*U. S. P. B. M. 21 ..	122.60	S	—1.4127	—0.9	0.6	8.2	145.2054	+0.1	145.2055	J.
		N.......	—1.4145	+0.9	......	......	....	......	....	F.
		Mean ..	—1.4136							
T. B. M. 75	126.51	S	—1.2050	+1.0	0.7	......	145.4150	......	....	J.
		N.......	—1.2030	—1.0	......	......	....	......	....	F.
		Mean ..	—1.2040							
T. B. M. 78	129.02	S	+2.6030	—0.8	0.6	......	148.0172	......	....	J.
		N.......	+2.6013	+0.9	......	......	....	......	....	F.
		Mean ..	+2.6022							
*U. S. P. B. M. 22 ..	129.04	S	+0.9630	......	......	8.2	148.9802	+0.1	148.9803	J.
T. B. M. 79	130.26	S	+0.2989	—0.7	0.5	......	148.3154	......	....	J.
		N.......	+0.2974	+0.8	......	......	....	......	....	F.
		Mean ..	+0.2982							
U. S. P. B. M. 23 ...	132.30	S	+0.6582	—1.8	1.2	8.3	148.9718	+0.1	148.9719	J.
		N.......	+0.6547	+1.7	......	......	....	......	....	F.
		Mean ..	+0.6564							
*P. B. M. 61, Mackenzie.	131.39	S	—1.9095	+1.0	0.7	8.4	147.0633	....	....	J.
		N.......	+1.9075	—1.0	......	......	....	......	....	F.
		Mean ..	—1.9085							
*H. W. 1851, at Louisiana, Mo.	131.86	N.......	—2.8545	......	......	......	146.1173	......	....	F.
*H. W. 1880, at Louisiana, Mo.	132.26	N.......	—4.3271	......	......	......	144.6447	......	....	F.
*H. W. 1881 (April), Louisiana, Mo.	132.26	N.......	—4.0681	......	......	......	144, 9037	......	....	F.
U. S. P. B. M. 24 ...	133.74	S	—0.2803	—0.9	0.6	8.4	148.6906	+0.1	148.6907	J.
		N.......	—0.2821	+0.9	......	......	....	......	....	F.
		Mean ..	—0.2812							
*H. W. 1881 (April) Louisiana, Mo.	132.42	N.......	—4.0285	......	......	......	144.9433	......	....	F.
*H. W. 1880, Louisiana, Mo.	132.42	N.......	—4.3252	......	......	......	144.6466	......	....	F.
*H. W., April 26, 1881, Louisiana, Mo.	....	N.......	—4.0678	......	......	......	144.6228	......	....	F.
*Zero of gauge on bridge at Louisiana, Mo.	134.05	....	—9.2708	—11.4	5.7	......	139.4312	......	....	F.
		....	—9.2537	+5.7	......	......	....	......	....	J.
		Mean ..	—9.2594							
T. B. M. 82	136.00	S	—3.9939	+0.3	0.2	......	144.6970	......	....	J.
		N.......	—3.9934	—0.2	......	......	....	......	....	F.
		Mean ..	—3.9936							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 85	138. 59	S	+3. 1569	—1. 6	1. 1	......	147. 8523	......	....	J.
		N	+3. 1537	+1. 6	......	......	....	......	....	F.
		Mean	+3. 1553							
U. S. P. B. M. 25	140. 02	S	—0. 5688	—0. 8	0. 6	......	147. 2827	+0. 1	147. 2828	J.
		N	—0. 5705	+0. 9	......	......	....	......	....	F.
		Mean	[illegible]							
T. B. M. 87	141. 07	S	[illegible]	[illegible]	[illegible]. 2	......	145. 9181	......	....	J.
		N	[illegible]	[illegible]	......	......	....	......	....	F.
		Mean	[illegible]							
T. B. M. 88	142. 29	S	[illegible]	[illegible]	[illegible]. 2	......	145. 9577	......	....	J.
		N	[illegible]	[illegible]	......	......	....	......	....	F.
		S	[illegible]	[illegible]	......	......	....	......	....	J.
		N	[illegible]	[illegible]	......	......	....	......	....	F.
		Mean	[illegible]							
*U. S. P. B. M. 26	143. 64	S	+[illegible]	[illegible]	[illegible]. 6	8. 6	146. 6471	+0. 1	146. 6472	J.
		N	+[illegible]	[illegible]	......	......	....	......	....	F.
		Mean	[illegible]							
T. B. M. 89	144. 08	S	[illegible]	[illegible]	1. 1	......	143. 6081	......	....	J.
		N	[illegible]	[illegible]	......	......	....	......	....	F.
		Mean	—[illegible]							
T. B. M. 91	145. 68	S	—0. 6939	—1. 1	0. 7	......	142. 9131	......	....	J.
		N	—0. 6960	+1. 0	......	......	....	......	....	F.
		Mean	—0. 6950							
T. B. M. 92	147. 02	S	+0. 0963	—1. 8	1. 2	......	143. 0076	......	....	J.
		N	+0. 0927	+1. 8	......	......	....	......	....	F.
		Mean	+0. 0945							
T. B. M. 94	147. 95	S	+4. 4392	—2. 3	0. 7	......	147. 4445	......	....	J.
		N	+4. 4346	+2. 3	......	......	....	......	....	F.
		S	+4. 4360	+0. 9	......	......	....	......	....	J.
		N	+4. 4379	—1. 0	......	......	....	......	....	F.
		Mean	+4. 4369							
*U. S. P. B. M. 27	148. 07	S	+0. 5737	0. 0	0. 0	8. 8	148. 0182	+0. 1	148. 0183	J.
		N	+0. 5737	0. 0	......	......	....	......	....	F.
		Mean	+0. 5737							
T. B. M. 95	148. 93	S	—1. 0499	+0. 1	0. 1	......	146. 3947	......	....	J.
		N	—1. 0497	—0. 1	......	......	....	......	....	F.
		Mean	—1. 0498							
*U. S. P. B. M. 28	149. 07	S	+0. 1658	+0. 4	0. 3	8. 8	146. 5609	+0. 1	146. 5610	J.
		N	+0. 1666	—0. 4	......	......	....	......	....	F.
		Mean	+0. 1662							
*H. W. 1876, Clarksville, Mo.	149. 15	N	—3. 4625	......	......	......	142. 9322	......	....	F.
*H. W. 1851, Clarksville, Mo.	149. 13	S	—1. 5284	......	......	......	144. 8663	......	....	J.
Rod station 1, Clarksville, Mo.	148. 98	S	—3. 7384	—0. 4	0. 3	......	142. 6559	......	....	J.
		N	—3. 7392	+0. 4	......	......	....	......	....	F.
		Mean	—3. 7388							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
Rod station 2, Island 463.	149.58		+0.0771	−0.5	0.3		142.7325			J.
			+0.0762	+0.4						F.
		Mean..	+0.0766							
Rod station 3	149.80	S	+0.0777	−0.5	0.3		142.8097			J.
		N	+0.0768	+0.4						F.
		Mean..	+0.0772							
Rod station 4	150.46		−0.7212	+1.1	0.7		142.0896			J.
			−0.7190	−1.1						F.
		Mean..	−0.7201							
Rod station 5	150.73		+0.8106	+1.0	0.7		142.9012			J.
			+0.8126	−1.0						F.
		Mean..	+0.8116							
*U. S. P. B. M. 29	150.83	S	−0.0161	−0.7	0.5	8.8	142.8844	+0.0	142.8844	J.
		N	−0.0175	+0.7						F.
		Mean..	−0.0168							
T. B. M. 97	152.75	S	−0.2629	+0.9	0.6		142.6392			J.
		N	−0.2612	−0.8						F.
		Mean..	−0.2620							
T. B. M. 99	155.15	S	+ 1.2087	0.0	0.0		143.8479			J.
		N	+ 1.2087	0.0						F.
		Mean..	+ 1.2087							
*U. S. P. B. M. 30	155.60	S	− 0.9795	−0.3	0.2	8.8	142.8681	0.0	142.8681	J.
		N	− 0.9801	+0.3						F.
		Mean..	− 0.9798							
T. B. M. 101	157.80	S	− 2.2617	−2.4	1.6		141.5838			J.
		N	− 2.2665	+2.4						F.
		Mean..	− 2.2641							
T. B. M. 102	159.76	S	+ 1.2668	−0.8	0.6		142.8498			J.
		N	+ 1.2651	+0.9						F.
		Mean..	+ 1.2660							
U. S. P. B. M. 31	161.18	S	− 0.8392	−0.4	0.2	9.0	142.0102	0.0	142.0102	J.
		N	− 0.8399	+0.3						F.
		Mean..	− 0.8396							
T. B. M. 104	162.18	S	− 0.9919	−0.9	0.6		141.0174			J.
		N	− 0.9936	+0.8						F.
		Mean..	− 0.9928							
T. B. M. 106	165.62	S	+ 0.3240	+2.1	1.4		141.3435			J.
		N	+ 0.3282	−2.1						F.
		Mean..	+ 0.3261							
U. S. P. B. M. 32	165.96	S	+ 7.2578	−1.4	0.9	9.2	148.5999	+0.1	148.6000	J.
		N	+ 7.2551	+1.3						F.
		Mean..	+ 7.2564							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 108	167.64	S.	− 7.8388	−0.1	0.1		140.7610			J.
		N.	− 7.8390	+0.1						F.
		Mean..	− 7.8389							
T. B. M. 109	168.93	S.	+ 2.4512	−3.2	1.1		143.2090			J.
		N.	+ 2.4455	+2.5						F.
		S.	+ 2.4474	+0.6						J.
		Mean..	+ [illegible]							
U. S. P. B. M. 33	170.24	S.	+1[illegible]	0.[illegible]	[illegible]2	9.2	163.0370	+0.2	163.0372	J.
		N.	+1[illegible]	0.[illegible]						F.
		Mean..	+19.8280							
T. B. M. 111	171.62	S.	−21.3869	−0.1	0.0		141.6500			J.
		N.	−21.3870	0.0						F.
		Mean..	−21.3870							
T. B. M. 113	174.58	S.	− 1.3173	+1.3	0.8		140.3340			J.
		N.	− 1.3148	−1.2						F.
		Mean..	− 1.3160							
T. B. M. 114	175.74	S.	+ 2.9823	−1.7	1.1		143.3146			J.
		N.	+ 2.9789	+1.7						F.
		Mean..	+ 2.9806							
*H. W., 1876, at Hamburg, Ill.	175.08	S.	− 2.0993				141.2153			J.
*H. W., April, 1881, at Hamburg, Ill.	175.08	S.	− 2.3136				141.0010			J.
*U. S. P. B. M. 34	175.84	S.	− 1.6244	+0.8	0.5	9.4	141.6910	0.0	141.6910	J.
		N.	− 1.6228	−0.8						F.
		Mean..	− 1.6236							
T. B. M. 115	176.76	S.	+ 4.9698	−1.0	0.7		146.2834			J.
		N.	+ 4.9677	+1.1						F.
		Mean..	+ 4.9688							
T. B. M. 116	177.85	S.	− 9.8379	+1.8	1.2		136.4473			J.
		N.	− 9.8343	−1.8						F.
		Mean..	− 9.8361							
U. S. P. B. M. 35	180.63	S.	+ 1.4701	−2.3	1.6	9.6	139.9151	0.0	139.9151	J.
		N.	+ 1.4654	+2.4						F.
		Mean..	+ 1.4678							
T. B. M. 119	181.60	S.	+ 0.4750	−0.8	0.6		140.3893			J.
		N.	+ 0.4724	+1.8						F.
		N.	+ 0.4751	−0.9						F.
		Mean..	+ 0.4742							
U. S. P. B. M. 36	182.96	S.	− 0.7301	+1.2	0.8	9.6	139.6604	0.0	139.6604	J.
		N.	− 0.7277	−1.2						F.
		Mean..	− 0.7289							
T. B. M. 123	186.24	S.	− 1.0281	−1.1	0.7		138.6312			J.
		N.	− 1.0303	+1.1						F.
		Mean..	− 1.0292							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r,	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 124	187.26	S	+ 0.6818	—4.4	1.0		139.8086			J.
		N	+ 0.6753	+2.1						F.
		S	+ 0.6767	+0.7						J.
		N	+ 0.6760	+1.4						F.
		Mean	+ 0.6774							
U. S. P. B. M. 37	187.92	S	+ 0.2593	+0.9	0.6	9.7	139.5688	0.0	139.5688	F.
		N	+ 0.2612	—1.0						F.
		Mean	+ 0.2602							
T. B. M. 125	189.28	S	— 1.1051	—2.5	1.7		138.4612			J.
		N	— 1.1102	+2.6						F.
		Mean	— 1.1076							
T. B. M. 126	189.99	S	— 0.1387	+0.5	0.3		138.3230			J.
		N	— 0.1377	—0.5						F.
		Mean	— 0.1382							
T. B. M. 127	191.95	S	— 0.4808	—0.6	0.4		137.8416			J.
		N	— 0.4820	+0.6						F.
		Mean	— 0.4814							
T. B. M. 128	192.72	S	+ 5.7191	—0.2	0.1		143.5605			J.
		N	+ 5.7187	+0.2						F.
		Mean	+ 5.7189							
T. B. M. 129	194.10	S	— 5.2789	+0.1	0.1		138.2817			J.
		N	— 5.2786	—0.2						F.
		Mean	— 5.2788							
U. S. P. B. M. 38	195.45	S	+ 0.4248	+0.4	0.3	9.9	138.7069	0.0	138.7069	J.
		N	+ 0.4256	—0.4						F.
		Mean	+ 0.4252							
T. B. M. 130	196.95	S	+ 0.2804	—2.2	1.5		138.9851			J.
		N	+ 0 2760	+2.2						F.
		Mean	+ 0.2782							
*U. S. P. B. M. 39	196.97	S	+ 0.5897	—0.1	0.1	10.0	139.5747	0.0	139.5747	J.
		N	+ 0.5895	+0.1						F.
		Mean	+ 0.5896							
T. B. M. 131	197.93	S	+ 0.8111	—1.3	0.9		139.7949			J.
		N	+ 0.8084	+1.3						F.
		Mean	+ 0.8098							
T. B. M. 132	200.00	S	— 1.1569	+0.3	0.2		138.6383			J.
		N	— 1.1562	—0.4						F.
		Mean	— 1.1566							
U. S. P. B. M. 40	200.51	S	— 0.0020	—1.2	0.8	10.1	138.6351	0.0	138.6351	J.
		N	— 0.0043	+1.1						F.
		Mean	— 0.0032							
T. B. M. 133	201.87	S	— 0.6435	+0.9	0.6		137.9925			J.
		N	— 0.6417	—0.9						F.
		Mean	— 0.6426							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 135	204. 91	S.	− 0. 8927	−1. 5	1. 0		137. 0983			J.
		N	− 0. 8956	+1. 4						F.
		Mean	− 0. 8942							
T. B. M. 136	205. 92	S.	+ 4. 2970	−4. 8	1. 1		141. 3905			J.
		N	+ 4. 2900	+2. 2						F.
		N	+ 4. 2903	+1. 9						F.
		S.	+ 4. 2913	+0. 9						J.
		Mean	+ 4. 2922							
*U. S. P. B. M. 41	205. 04	S.	+ 0. 5742	+0. 4	0. 3	10. 2	141. 9651	0. 0	141. 9651	J.
		N	+ 0. 5750	−0. 4						F.
		Mean	+ 0. 5746							
T. B. M. 137	206. 74	S.	− 6. 8958	−0. 1	0. 1		134. 4946			J.
		N	− 6. 8960	+0. 1						F.
		Mean	− 6. 8959							
T. B. M. 138	207. 62	S.	+ 4. 2674	−2. 9	1. 0		138. 7591			J.
		N	+ 4. 2629	+1. 6						F.
		S.	+ 4. 2631	+1. 4						J.
		Mean	+ 4. 2645							
T. B. M. 139	209. 24	S.	− 1. 4816	+1. 2	0. 8		137. 2787			J.
		N	− 1. 4792	−1. 2						F.
		Mean	− 1. 4804							
T. B. M. 140	209. 93	S.	−2. 5327	−3. 9	0. 9		134. 7421			J.
		N	−2. 5376	+1. 0						F.
		S.	−2. 5381	+1. 5						J.
		N	−2. 5382	+1. 6						F.
		Mean	−2. 5366							
*U. S. P. B. M. 42	210. 09	S.	+6. 3438	+0. 4	0. 3	10. 3	141. 0863	0. 0	141. 0863	F.
		N	+6. 3446	−0. 4						F.
		Mean	+6. 3442							
T. B. M. 141	211. 52	S.	+0. 1215	−3. 8	1. 2		134. 8598			J.
		N	+0. 1133	+4. 4						F.
		S.	+0. 1187	−1. 0						J.
		N	+0. 1174	+0. 3						F.
		Mean	+0. 1177							
T. B. M. 141½	212. 41	S.	−0. 8184	−3. 3	0. 8		134. 0381			J.
		N	−0. 8234	+1. 7						F.
		N	−0. 8229	+1. 2						J.
		S.	−0. 8220	+0. 3						J.
		Mean	−0. 8217							
T. B. M. 143	214. 52	S.	+3. 3567	−1. 7	1. 1		137. 3931			J.
		N	+3. 3534	+1. 6						F.
		Mean	+3. 3550							
*U. S. P. B. M. 43	214. 53	S.	+1. 5071	+0. 1	0. 0	10. 5	138. 9003	0. 0	138. 9003	J.
		N	+1. 5072	0. 0						F.
		Mean	+1. 5072							

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 145	217. 02	S	—3. 7711	—0. 5	0. 3	......	133. 6215	......	....	J.
		N	—3. 7721	+0. 5	......	......	....	......	....	F.
		Mean..	—3. 7716							
T. B. M. 146	217. 53	S	+2. 6297	—0. 1	0. 1	......	136. 2511	......	....	J.
		N	+2. 6294	+0. 2	......	......	....	......	....	F.
		Mean..	+2. 6296							
*U. S. P. B. M. 44 ..	217. 54	S	+2. 5244	0. 0	0. 0	10. 5	138. 7755	0. 0	138. 7755	J.
		N	+2. 5245	0. 1	......	......	....	......	....	F.
		Mean..	+2. 5244							
T. B. M. 148	219. 65	S	—0. 2916	0. 0	0. 0	......	135. 9595	......	....	J.
		N	—0. 2915	—0. 1	......	......	....	......	....	F.
		Mean..	—0. 2916							
T. B. M. 150	222. 15	S	—0. 3725	—0. 7	0. 4	......	135. 5863	......	....	J.
		N	—0. 3738	+0. 6	......	......		......	....	F.
		Mean..	—0. 3732							
T. B. M. 151	222. 48	S	—0. 1989	—0. 3	0. 2	......	135. 3871	......	....	J.
		N	—0. 1995	+0. 3	......	......	....	......	....	F.
		Mean..	—0. 1902							
*U. S. P. B. M. 45 ..	222. 49	S	+1. 6279	—0. 1	0. 0	10. 5	137. 0149	0. 0	137. 0149	J.
		N	+1. 6:78	0. 0	......	......	....	......	....	F.
		Mean..	+1. 6278							
T. B. M. 152	224. 47	S	—0. 2608	+0. 8	0. 6	......	135. 1271	......	....	J.
		N	—0. 2591	—0. 9	......	......	....	......	....	F.
		Mean..	—0. 2600							
T. B. M. 153	226. 85	S	—1. 8797	+2. 3	1. 5	......	133. 2497	......	....	J.
		N	—1. 8751	—2. 3	......	......	....	......	....	F.
		Mean..	—1. 8774							
*U. S. P. B. M. 46 ..	226. 84	S	+11. 4218	—0. 1	0. 1	10. 6	144. 6714	+01.	144. 6715	J.
		N	+11. 4216	+0. 1	......	......	....	......	....	J.
		Mean..	+11. 4217							
T. B. M. 155	229. 14	S	+0. 6094	—1. 0	0. 7	......	133. 8581	......	....	J.
		N	+0. 6074	+1. 0	......	......	....	......	....	F.
		Mean..	+0. 6084							
T. B. M. 156	230. 23	S	+3. 5679	+2. 1	1. 4	......	137. 4281	......	....	J.
		N	+3. 5720	—2. 0	......	......	....	......	....	F.
		Mean..	+3. 5700							
*U. S. P. B. M. 47 ..	230. 24	S	+0. 4071	+0. 3	0. 2	10. 7	137. 8355	0. 0	137. 8355	J.
		N	+0. 4078	—0. 4	......	......	....	......	....	F.
		Mean..	+0. 4074							
T. B. M. 157	231. 82	S	—1. 1733	—2. 9	1. 9	......	136. 2519	......	....	J.
		N	—1. 1791	+2. 9	......	......	....	......	....	F.
		Mean..	—1. 1762							
*H. W., spring of 1881.	231. 89	....	—0. 6074	......	......	......	135. 6445	......	....	F.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 158	233.88	S.	−0.6612	+2.0	1.3		135.5927			J.
		N.	−0.6572	−2.0						F.
		Mean..	−0.6592							
T. B. M. 160	236.10	S.	+0.8102	−0.2	0.2		136.4027			J.
		N.	+0.8097	+0.3						F.
		Mean.	+[illegible]							
T. B. M. 161	237.21	S.	[illegible]	[illegible]	0.5		133.7233			J.
		N.	[illegible]	[illegible]						R.
		Mean..	−1.67[illegible]							
U. S. P. B. M. 1 (Grafton).	239.39	S.	+[illegible]	[illegible]	2.0	11.2	134.5035	0.0	134.5035	J.
		N.	+[illegible]	[illegible]						F.
		Mean..	+0.7802							
Rod Station 1	239.49	S.	−3.5792	−0.6	0.3		130.9237			J.
		N.	−3.5806	+0.8						F.
		S.	−3.5787	−1.1						R.
		N.	−3.5808	+1.0						R.
		Mean..	−3.5798							
Rod Station 2 (crossing Illinois River).	239.85	S.	+0.0927	−4.3	2.7		131.0121			J.
		N.	+0.0828	+5.6						J.
		N.	+0.0806	+7.8						F.
		S.	+0.0976	−9.2						F.
		Mean..	+0.0884							
U. S. P. B. M. 2 (Grafton).	240.03	S.	+5.3498	+0.1	0.1	11.5	136.3620	0.0	136.3620	J.
		N.	+5.3500	−0.1						R.
		Mean..	+5.3499							
*H. W., April, 1881	241.36		−0.0425				136.3195			F.
U. S. P. B. M. 3 (Grafton).	242.17	S.	+2.9502	−0.6	0.4	11.5			†139.3116	F.
		N.	+2.9491	+0.5						R.
		Mean..	+2.9496							
*P. B. M. 66 of Captain Mackenzie. Referred to Mackenzie B. M.		S.	−4.7040	+0.2	0.2		134.7258			F.
		N.	−4.7035	−0.3						F.
		Mean..	−4.7038							

Elevation, Mackenzie B. M., 139.4296. See page —.

†The elevation of U. S. P. B. M. 3, as given on page —, is taken as the initial elevation for all poin north of Grafton. This bench-mark is on the Catholic church steps, and is believed to be more like to have remained undisturbed than U. S. P. B. M.'s 1 and 2, which are stone posts set in the groun The discrepancy between the determinations of difference of elevations of U. S. P. B. M. 1 and 3, ma in 1880 and 1881, is 6.6mm, that of 1881 being the larger.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T.B.M. 98 and 98a	132.22	N	−0.0956	−1.4	0.9		169.5434			P.	F.
		S	−0.0984	+1.4						P.	F.
		Mean	−0.0970								
T.B.M. 99	133.37	N	+1.1632	−0.4	0.3		170.7062			P.	F.
		S	+1.1624	+0.4						P.	F.
		Mean	+1.1628								
T.B.M. 100	134.64	N	−0.5866	−0.6	0.4		170.1190			P.	J.
		S	−0.5877	+0.5						P.	J.
		Mean	−0.5872								
T.B.M. 101	135.46	N	−0.6478	+0.9	0.6		169.4721			P.	J.
		S	−0.6460	−0.9						P.	J.
		Mean	−0.6469								
T.B.M. 102	136.03	N	−0.2514	+2.0	0.6		169.2227			P.	F.
		S	−0.2470	−2.4						P.	F.
		N	−0.2493	−0.1						P.	F.
		S	−0.2501	+0.7						P.	F.
		Mean	−0.2494								
T.B.M. 103	136.18	N	−0.3069	−0.5	0.4		168.9153			P.	F.
		S	−0.3080	+0.6						P.	F.
		Mean	−0.3074								
T.B.M. 104	136.42	N	+0.0031	−0.2	0.1		168.9182			P.	J.
		S	+0.0027	+0.2						P.	J.
		Mean	+0.0029								
T.B.M. 105	136.06	N	−0.0307	+0.4	0.3		168.9178			(*)	J.
		S	+0.0290								J.
		N	−0.0212	−0.5							F.
		S	+0.0214								F.
		Mean	−0.0004								
T.B.M. 106	138.60	N	+2.1153	+4.0	1.1		171.0371			P.	J.
		S	+2.1231	−3.8						P.	J.
		N	+2.1188	+0.5						P.	J.
		S	+2.1199	−0.6						P.	J.
		Mean	+2.1193								
T.S.P.B.M. 24= Mackenzie B.M. 6	138.62	S	+1.2697	+0.1	0.0	7.7	172.3069	+0.5	172.3074		J.
		S	+1.2698	0.0							F.
		Mean	+1.2698								
T.B.M. 107	139.61	N	−1.1292	+4.2	1.0		169.9121			P.	J.
		S	−1.1232	−1.8						P.	J.
		N	−1.1250	0.0						P.	F.
		S	−1.1228	−2.2						P.	F.
		Mean	−1.1250								
T.B.M. 108 and 108a	141.24	N	−0.6700	+0.4	0.2		169.2425			P.	F.
		S	−0.6693	−0.3						P.	F.
		Mean	−0.6696								
T.B.M. 109	142.36	N	+1.0217	−0.1	0.0		170.2641			P.	F.
		S	+1.0216	0.0						P.	F.
		Mean	+1.0216								

* River crossing.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
*H. W. Mark, 1881, Port Louisa, Iowa.	141.86	S	+1.0536				171.3177			P.
T. B. M. 110	144.03	N	+0.3250	—2.9	1.1		170.5862			P.
		S	+0.3194	+2.7						P.
		N	+0.3218	+0.3						P.
		Mean	+0.3221							
T. B. M. 111	145.71	N	+0.3540	—0.5	0.3		170.9397			P.
		S	+0.3530	+0.5						P.
		Mean	+0.3535							
T. B. M. 112	146.30	N	—0.3593	—1.8	1.2		170.5786			P.
		S	—0.3629	+1.8						P.
		Mean	—0.3611							
T. B. M. 113	146.98	N	+0.4048	+0.1	0.1		170.9835			P.
		S	+0.4050	—0.1						P.
		Mean	+0.4049							
T. B. M. 114 and 114*a*.	147.81	N	+1.3335	—1.5	1.0		172.3155			P.
		S	+1.3306	+1.4						P.
		Mean	+1.3320							
T. B. M. 115	148.80	N	+0.2448	—3.2	1.1		172.5571			P.
		S	+0.2398	+1.8						P.
		N	+0.2401	+1.5						P.
		Mean	+0.2416							
T. B. M. 116	149.32	N	—1.0220	—0.6	0.4		171.5345			P.
		S	—1.0231	+0.5						P.
		Mean	—1.0226							
T. B. M. 117	150.72	N	+0.0247	—1.1	0.7		171.5581			P.
		S	+0.0225	+1.1						P.
		Mean	+0.0236							
*U. S. P. B. M. 25	150.85	S	+0.4415	+0.9	0.6	8.1	172.0005	+0.5	172.0010	P.
		N	+0.4434	—1.0						P.
		Mean	+0.4424							
*H. W. Mark, June, 1880.	150.85	N	+0.3606				171.9187			
*H. W. Mark, 1851	150.90	N	+0.0010				172.0015			
*H. W. Mark, Oct., 1881.	150.90	N	—0.0157				171.9848			
T. B. M. 118	151.65	N	+1.5861	+1.9	1.3		173.1461			P.
		S	+1.5899	—1.9						P.
		Mean	+1.5880							
*U. S. P. B. M. 26	151.68	N	+0.1078			8.2	173.2539	+0.5	173.2544	
T. B. M. 119	152.95	N	—1.8469	—0.5	0.3		171.2987			P.
		S	—1.8478	+0.4						P.
		Mean	—1.8474							
T. B. M. 120 and 120*a*.	154.62	N	+0.9804	—0.6	0.4		172.2785			P.
		S	+0.9791	+0.7						P.
		Mean	+0.9798							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
M. 18 and 18a	30.42	S.	+5.7398	+1.4	0.9		177.1122			P.	J.
		N.	+5.7426	−1.4						P.	J.
		Mean	+5.7412								
.M. 19 and 19a	31.91	S.	−5.9833	−1.8	1.2		171.1271			P.	J.
		N.	−5.9870	+1.9						P.	J.
		Mean	−5.9851								
.M. 20	33.64	S.	−1.2207	−0.6	0.4		169.9058			P.	J.
		N.	−1.2219	+0.6						P.	J.
		Mean	−1.2213								
B.M. 22	35.32	N.	−1.1248	+0.5	0.3		168.7815			P.	F.
		S.	−1.1239	−0.4						P.	F.
		Mean	−1.1243								
B.M. 23	36.87	N.	−2.5940	−1.4	0.9		166.1861			P.	F.
		S.	−2.5968	+1.4						P.	F.
		Mean	−2.5954								
.B.M. 24	38.56	S.	−0.0346	−0.7	0.5		166.1508			P.	F.
		N.	−0.0360	+0.7						P.	F.
		Mean	−0.0353								
.S.P.B.M. 7	38.69	N.	+2.8397	+0.1	0.1	3.8	168.9906	+0.4	168.9910	P.	J.
		S.	+2.8400	−0.2						P.	F.
		Mean	+2.8398								
.B.M. 25	39.50	N.	−2.7120	−0.3	0.2		166.2783			P.	J.
		S.	−2.7126	+0.3						P.	F.
		Mean	−2.7123								
U.S.P.B.M. 8	39.57	N.	+4.2845	−0.4	0.2	3.8	170.5624	+0.4	170.5628	P.	J.
		S.	+4.2838	+0.3						P.	F.
		Mean	+4.2841								
T.B.M. 26	40.29	N.	−1.4030	−0.2	0.2		164.8751			P.	F.
		S.	−1.4035	+0.3						P.	F.
		Mean	−1.4032								
T.B.M. 27 and 27a	41.90	N.	+0.6605	+1.9	1.3		165.5375			P.	F.
		S.	+0.6644	−2.0						P.	F.
		Mean	+0.6624								
T.B.M. 28	43.33	N.	+5.3031	0.0	0.0		170.8406			P.	F.
		S.	+5.3032	−0.1						P.	F.
		Mean	+5.3031								
T.B.M. 29 and 29a	44.87	N.	−5.3617	+2.2	0.6		165.4811			P.	J.
		N.	−5.3605	+1.0						F.	J.
		S.	−5.3552	−4.3						P.	J.
		S.	−5.3592	−0.3						F.	J.
		S.	−5.3604	+0.9						P.	J.
		S.	−5.3601	+0.6						F.	J.
		Mean	−5.3595								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.	
T. B. M. 30	45.52	N	+4.9114	+0.6	0.2		170.3931			P.
		N	+4.9121	—0.1						F.
		S	+4.9117	+0.3						P.
		S	+4.9129	—0.9						F.
		Mean	+4.9120							
*U. S. P. B. M. 9	45.70	N	+2.0966	+0.6	0.3	4.1	172.4903	+0.5	172.4908	P.
		S	+2.0982	—1.0						P.
		S	[illegible]	[illegible]						P.
		Mean	[illegible]							
T. B. M. 31	45.77	N	[illegible]	[illegible]	0.1		171.5786			P.
		N	[illegible]	[illegible]						F.
		S	[illegible]	[illegible]						P.
		S	[illegible]	[illegible]						F.
		Mean	[illegible]							
T. B. M. 32	46.70	N	[illegible]	+2.5	0.9		165.7976			P.
		S	[illegible]	—2.3						P.
		S	[illegible]	—0.1						P.
		Mean	—5.7810							
T. B. M. 33 and 33a	47.53	N	+0.9247	+0.8	0.5		166.7231			P.
		S	+0.9263	—0.8						P.
		Mean	+0.9255							
T. B. M. 34	48.94	N	+4.9363	—0.1	0.1		171.6593			P.
		S	+4.9361	+0.1						P.
		Mean	+4.9362							
T. B. M. 35 and 35a	50.58	N	—1.5295	+2.3	0.6		170.1321			P.
		N	—1.5258	—1.4						F.
		S	—1.5264	—0.8						P.
		S	—1.5271	—0.1						F.
		Mean	—1.5272							
T. B. M. 36	52.19	N	+0.0061	—3.6	0.9		170.1346			P.
		N	+0.0004	+2.1						F.
		S	+0.0005	+2.0						P.
		S	+0.0030	—0.5						F.
		Mean	+0.0025							
U. S. P. B. M. 10	53.71	N	+2.9911	—2.2	1.4	4.6	173.1235	+0.5	173.1240	P.
		S	+2.9868	+2.1						P.
		Mean	+2.9889							
T. B. M. 37	54.92	N	+2.6984	+1.8	1.2		175.8237			P.
		S	+2.7020	—1.8						P.
		Mean	+2.7002							
T. B. M. 38 and 38a	55.70	N	—1.6462	+1.9	0.7		174.1794			P.
		N	—1.6456	+1.3						F.
		S	—1.6417	—2.6						P.
		S	—1.6438	—0.5						F.
		Mean	—1.6443							
T. B. M. 39	56.46	S	—0.0696	—2.6	0.8		174.1072			P.
		S	—0.0707	—1.5						F.
		N	—0.0749	+2.7						P.
		N	—0.0735	+1.3						F.
		Mean	—0.0722							

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
B.M.40 and 40a.	57.74	N.......	+0.0444	+0.5	0.3	......	174.1521	......	....	P.	F.
		S.......	+0.0454	−0.5	......	......	....	......	....	P.	F.
		Mean..	+0.0449								
B.M.41 and 41a.	59.28	N.......	−0.5881	−1.6	1.1	......	173.5624	......	....	P.	F.
		S.......	−0.5914	+1.7	......	......	....	......	....	P.	F.
		Mean..	−0.5897								
U.S.P.B.M. 11..	59.85	N.......	−2.8540	+0.3	0.2	5.0	170.7087	+0.4	170.7091	{P. F.}	J.
		N.......	−2.8535	−0.2	......	......	....	......	....	{P. F.}	J. F.
		Mean..	−2.8537								
B.M.42 and 42a.	60.83	S.......	−5.1594	−3.7	0.9	......	168.3993	......	....	P.	J.
		S.......	−5.1628	−0.3	......	......	....	......	....	F.	J.
		N.......	−5.1652	+2.1	......	......	....	......	....	P.	J.
		N.......	−5.1651	+2.0	......	......	....	......	....	F.	J.
		Mean..	−5.1631								
B.M.43 and 43a.	62.13	S.......	−1.0536	+1.0	0.5	......	167.3467	......	....	P.	J.
		S.......	−1.0535	+0.9	......	......	....	......	....	F.	J.
		N.......	−1.0504	−2.2	......	......	....	......	....	P.	J.
		N.......	−1.0529	+0.3	......	......	....	......	....	F.	J.
		Mean..	−1.0526								
B.M.44 and 44a.	63.80	S.......	+0.4902	+1.7	1.2	......	167.8386	......	....	P.	F.
		N.......	+0.4937	−1.8	......	......	....	......	....	P.	F.
		Mean..	+0.4919								
B.M.45 and 45a.	65.52	S.......	+0.1928	−0.5	0.3	......	168.0309	......	....	P.	F.
		N.......	+0.1918	+0.5	......	......	....	......	....	P.	F.
		Mean..	+0.1923								
U.S.P.B.M. 12..	66.37	S.......	+0.1333	+1.2	0.8	5.3	168.1654	+0.3	168.1657	P.	F.
		N.......	+0.1357	−1.2	......	......	....	......	....	P.	{J. F.}
		Mean..	+0.1345								
B.M.46........	66.93	S.......	+2.3135	−0.6	0.4	......	170.3438	......	....	P.	F.
		N.......	+2.3124	+0.5	......	......	....	......	....	P.	F.
		Mean..	+2.3129								
U.S.P.B.M. 13...	68.06	S.......	+1.0521	+0.5	0.3	5.2	171.3964	+0.4	171.3968	P.	J.
		S.......	+1.0518	+0.8	......	......	....	......	....	F.	J.
		N.......	+1.0541	−1.5	......	......	....	......	....	P.	J.
		N.......	+1.0526	0.0	......	......	....	......	....	F.	J.
		Mean..	+1.0526								
ft. mark of ...er-gauge at ...rlington ...dge, Iowa.	68.58	....	−3.8399	+5.4	3.6	......	167.5619	......	....	{P. F.}	J.
		....	−3.8291	−5.4	......	......	....	......	....	P.	{J. F.}
		Mean..	−3.8345								
B.M.47........	69.74	N.......	+0.0382	−1.2	0.6	......	171.4334	......	....	(†)	J.
		S.......	+0.0386	−1.6	......	......	....	......	....	(†)	J.
		N.......	+0.0365	+0.5	......	......	....	......	....	(†)	F.
		S.......	+0.0348	+2.2	......	......	....	......	....	(†)	F.
		Mean..	+0.0370								

† Bridge crossing.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*T. B. M. 49, Mackenzie.	69.77	N.......	+0.0071	......	......	5.3	171.4405	+0.4	171.4409	F.
U. S. P. B. M. 14 ...	69.78	N.......	+0.0011	+0.3	0.2	5.3	171.4348	+0.4	171.4352	...
		S	+0.0017	−0.3	......	......	......	......	......	...
		Mean ..	+0.0014							
T. B. M. 47½	70.86	N.......	−2.9537	−1.7	1.0	......	168.4794	......	......	F.
		S	−2.9600	+4.6	......	......	......	......	......	F.
		S	−2.9542	−1.2	......	......	......	......	......	P.
		S	−2.9538	−1.6	......	......	......	......	......	F.
		Mean ..	−2.9554							
T. B. M. 48	71.39	N.......	−0.6837	+0.2	0.1	......	167.7959	......	......	F.
		S	−0.6833	−0.2	......	......	......	......	......	F.
		Mean ..	−0.6835							
T.B.M.49 and 49a.	72.75	N.......	−0.1559	−0.6	0.4	......	167.6394	......	......	P.
		S	−0.1571	+0.6	......	......	......	......	......	P.
		Mean ..	−0.1565							
U. S. P. B. M. 15 ...	73.17	S	+0.0361	+0.6	0.4	5.4	167.6761	+0.3	167.6764	P.
		N.......	+0.0373	−0.6	......	......	......	......	......	P.
		Mean ..	+0.0367							
T.B.M.50 and 50a.	74.51	S	+0.2400	+1.0	0.7	......	167.9171	......	......	P.
		N.......	+0.2421	−1.1	......	......	......	......	......	P.
		Mean ..	+0.2410							
T. B. M. 51	75.45	N.......	−0.0500	−0.5	0.4	......	167.8666	......	......	F.
		S	−0.0511	+0.6	......	......	......	......	......	F.
		Mean ..	−0.0505							
T.B.M.52 and 52a.	76.23	N.......	+0.0799	+0.9	0.6	......	167.9474	......	......	F.
		S	+0.0818	−1.0	......	......	......	......	......	F.
		Mean ..	+0.0808							
T. B. M. 53	77.13	N.......	+0.2068	−1.1	0.7	......	168.1531	......	......	F.
		S	+0.2046	+1.1	......	......	......	......	......	F.
		Mean ..	+0.2057							
T. B. M. 54	78.58	N.......	+0.0108	−2.6	1.8	......	168.1613	......	......	F.
		S	+0.0055	+2.7	......	......	......	......	......	F.
		Mean ..	+0.0082							
*U. S. P. B. M. 16 .	78.60	N.......	+0.0018	+0.1	0.1	5.8	168.1632	+0.3	168.1635	...
		N.......	+0.0021	−0.2	......	......	......	......	......	...
		Mean ..	+0.0019							
T. B. M. 55	79.80	N.	+0.4836	+1.6	1.1	......	168.6465	......	......	P.
		S	+0.4869	−1.7	......	......	......	......	......	P.
		Mean ..	+0.4852							
T. B. M. 56 and 56a	81.17	N.......	+3.3703	+1.4	0.9	......	172.0182	......	......	P.
		S	+3.3730	−1.3	......	......	......	......	......	P.
		Mean ..	+3.3717							
T. B. M. 56 A	83.07	S	−0.3153	+0.3	0.2	......	171.7032	......	......	P.
		N.......	−0.3147	−0.3	......	......	......	......	......	P.
		Mean ..	−0.3150							

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.		
B. M. 56 B. and 56 B'.	83.88	S	−2.8566	+0.8	0.5	......	168.8474	......	....	P.	J.
		N	−2.8551	−0.7	......	......	....	......	....	P.	J.
		Mean..	−2.8558								
B. M. 57	84.34	S	+1.4624	+0.8	0.5	......	170.3106	......	....	P.	J.
		N	+1.4639	−0.7	......	......	....	......	....	P.	J.
		Mean..	+1.4632								
B. M. 58 and 58a	85.30	S	−1.3600	+3.4	0.7	......	168.9540	......	....	P.	J.
		N	−1.3501	−6.5	......	......	....	......	....	P.	J.
		N	−1.3557	−0.9	......	......	....	......	....	P.	J.
		N	−1.3557	−0.9	......	......	....	......	....	F.	J.
		S	−1.3575	+0.9	......	......	....	......	....	P.	J.
		S	−1.3562	−0.4	......	......	....	......	....	F.	J.
		N	−1.3584	+1.8	......	......	....	......	....	P.	J.
		N	−1.3589	+2.3	......	......	....	......	....	F.	J.
		Mean..	−1.3566								
B. M. 59 and 59a	86.63	S	−0.7065	−1.1	0.8	......	168.2464	......	....	P.	F.
		N	−0.7088	+1.2	......	......	....	......	....	P.	F.
		Mean..	−0.7076								
B. M. 60	87.84	N	+0.5054	+0.6	0.4	......	168.7524	......	....	P.	F.
		S	+0.5067	−0.7	......	......	....	......	....	P.	F.
		Mean..	+0.5060								
B. M. 61 and 61a	89.06	N	−0.6258	+1.0	0.7	......	168.1276	......	....	P.	F.
		S	−0.6237	−1.1	......	......	....	......	....	P.	F.
		Mean..	−0.6248								
B. M. 62	90.64	N	+0.7707	+1.5	1.0	......	168.8998	......	....	P.	F.
		S	+0.7737	−1.5	......	......	....	......	....	P.	F.
		Mean..	+0.7722								
P. B. M. 17 ..	90.66	S	+0.6258	+0.2	0.1	6.3	169.5258	+0.4	169.5262	....	F.
		N	±0.6262	−0.2	......	......	....	......	....	....	J.
		Mean..	+0.6260								
P. B. M. 18 ..	90.84	N	+4.2359	+0.5	0.3	6.3	173.1362	+0.5	173.1367	....	J.
		S	+4.2369	−0.5	......	......	....	......	....	....	F.
		Mean..	+4.2364								
B. M. 48, Mackie.	90.66	N	−0.0034	−0.2	0.1	6.3	168.8962	+0.4	168.8966	....	F.
		N	−0.0038	+0.2	......	......	....	......	....	....	J.
		Mean..	−0.0036								
W. mark, 1851, Nauvoo, Ill.	90.69	N	+0.0617	−2.5	1.6	......	168.9590	......	....	....	J.
		N	+0.0568	+2.4	......	......	....	......	....	....	F.
		Mean..	+0.0592								
B. M. 63 and 63a	91.40	N	+5.1117	−1.0	0.7	......	174.0105	......	....	P.	F.
		S	+5.1097	+1.0	......	......	....	......	....	P.	F.
		Mean..	+5.1107								
B. M. 64	92.14	N	+3.8966	0.0	0.0	......	177.9071	......	....	F.	J.
		S	+3.8965	+0.1	......	......	....	......	....	F.	J.
		Mean..	+3.8966								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*U. S. P. B. M. 39..	209.02	N.......	—0.0061	+0.1	0.1	9.7	180.8742	+0.7	180.8749	....
		S.......	—0.0059	—0.1	......	......	....	......	....	....
		Mean..	—0.0060							
T. B. M. 173.......	209.68	N.......	—1.4397	—0.5	0.3	......	179.4400	......	....	F.
		S.......	—1.4407	+0.5	......	......	....	......	....	F.
		Mean..	—1.4402							
*Zero of gauge at Rock Island Bridge.	209.96	N.......	—8.0315	......	......	......	171.4085	......	....	....
*U. S. P. B. M. 40..	209.80	N.......	+2.6728	+0.4	0.2	9.7	182.1132	+0.7	182.1139	....
		S.......	+2.6735	—0.3	......	......	....	......	....	....
		Mean..	+2.6732							
*Astronomical post, Rock Island.	210.07	N.......	—0.4391	+0.1	0.1	......	179.0010	+0.7	179.0017	....
		S.......	—0.4388	—0.2	......	......	....	......	....	....
		Mean..	—0.4390							
*H. W., 1880......	209.96	N.......	—2.4233	......	......	......	177.0167	......	....	....
T. B. M. 175.......	211.52	N.......	+0.6892	—1.3	0.9	......	180.1279	......	....	F.
		S.......	+0.6866	+1.3	......	......	....	......	....	F.
		Mean..	+0.6879							
*U. S. P. B. M. 41..	211.86	N.......	+3.1766	0.0	0.0	9.7	183.3045	+0.8	183.3053	....
		S.......	+3.1767	—0.1	......	......	....	......	....	....
		Mean..	+3.1766							
T. B. M. 176 and 176*a*.	213.51	N.......	+1.5206	0.0	0.0	......	181.6485	......	....	F.
		S.......	+1.5207	—0.1	......	......	....	......	....	F.
		Mean..	+1.5206							
T. B. M. 177.......	214.36	N.......	—1.3763	+1.9	1.2	......	180.2741	......	....	F.
		S.......	—1.3726	—1.8	......	......	....	......	....	F.
		Mean..	—1.3744							
*U. S. P. B. M. 42..	214.55	N.......	—0.7034	—0.6	0.4	9.8	179.5701	+0.7	179.5708	....
		S.......	—0.7046	+0.6	......	......	....	......	....	....
		Mean..	—0.7040							
T. B. M. 178.......	215.15	N.......	+0.5246	+0.4	0.2	......	180.7991	......	....	F.
		S.......	+0.5253	—0.3	......	......	....	......	....	F.
		Mean..	+0.5250							
T. B. M. 179.......	216.22	N.......	+0.1589	+1.6	1.1	......	180.9596	......	....	F.
		S.......	+0.1621	—1.6	......	......	....	......	....	F.
		Mean..	+0.1605							
T. B. M. 180.......	217.28	N.......	+0.3918	—2.0	1.8	......	181.3494	......	....	F.
		S.......	+0.3879	+1.9	......	......	....	......	....	F.
		Mean..	+0.3898							
T. B. M. 181.......	218.27	N.......	—1.4885	—0.1	0.0	......	179.8608	......	....	P
		S.......	—1.4886	0.0	......	......	....	......	....	P
		Mean..	—1.4886							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 79 and 79a	111.00	N	−1.7230	−0.5	0.3		169.3046			F.	F.
		S	−1.7240	+0.5						F.	F.
		Mean	−1.7235								
*U. S. P. B. M. 19	111.47	N	+1.3198	+0.4	0.2	6.9	170.6248	+0.4	170.6252	F.	J.
		S	+1.3205	−0.3						F.	J.
		Mean	+1.3202								
*U. S. P. B. M. 20	111.30	N	+4.3437			6.9	173.6483	+0.5	173.6488	F.	J.
*T. B. M. 47, Mackenzie.	111.54	N	+1.3181			6.9	170.6227	+0.4	170.6231	F.	J.
*H. W. mark, 1851, Keithsburg, Ill.	111.54	N	+1.0881				170.3927			F.	J.
*H. W. mark, 1881, Keithsburg, Ill.	111.62	N	+0.6733				169.9779			F.	J.
T. B. M. 80	111.40	N	+1.0671	−0.3	0.2		170.3714			F.	F.
		S	+1.0664	+0.4						F.	F.
		Mean	+1.0668								
T. B. M. 81 and 81a	111.87	N	+2.6500	−0.6	0.4		173.0208			F.	F.
		S	+2.6487	+0.7						F.	F.
		Mean	+2.6494								
T. B. M. 82 and 82a	113.40	N	+6.2676	−1.6	1.1		179.2868			F.	F.
		S	+6.2643	+1.7						F.	F.
		Mean	+6.2660								
T. B. M. 83 and 83a	114.63	N	+0.8725	+0.2	0.1		180.1595			F.	F.
		S	+0.8729	−0.2						F.	F.
		Mean	+0.8727								
T. B. M. 84	116.10	N	+0.7559	+4.0	1.1		180.9194			F.	J.
		S	+0.7039	−4.0						F.	J.
		N	+0.7596	+0.3						F.	J.
		S	+0.7603	−0.4						F.	J.
		Mean	+0.7599								
T. B. M. 85 and 85a	117.45	N	−0.0186	+1.3	0.9		180.9021			F.	J.
		S	−0.0160	−1.3						F.	J.
		Mean	−0.0173								
T. B. M. 86	118.75	N	−0.6858	−0.6	0.4		180.2157			F.	J.
		S	−0.6870	+0.6						F.	J.
		Mean	−0.6864								
T. B. M. 87	119.81	N	−1.1346	−1.8	1.2		179.0793			F.	J.
		S	−1.1383	+1.9						F.	J.
		Mean	−1.1364								
T. B. M. 88 and 88a	120.82	N	−3.8750	−1.2	0.8		175.2031			F.	J.
		S	−3.8775	+1.3						F.	J.
		Mean	−3.8762								
*U. S. P. B. M. 21	120.84	N	+0.0590	−0.4	0.2	7.8	175.2617	+0.5	175.2622		F.
		S	+0.0583	+0.3							F.
		Mean	+0.0586								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 89 and 89*a*	124.24	N.......	+2.0934	—0.3	0.2	......	177.2962	......	....	F.
		S.......	+2.0928	+0.3	......	......	....	......	....	F.
		Mean..	+2.0931							
U. S. P. B. M. 22 ..	124.56	N.......	—5.0325	—0.3	0.2	7.3	172.2634	+0.5	172.2639	F.
		S.......	—5.0331	+0.3	......	......	....	......	....	F.
		[illegible]	[illegible]	[illegible]						
*P. B. M. 46, Mackenzie.	124.77	N....	[illegible]	[illegible]	0.0	......	170.5779	+0.4	170.5783	....
		S....	[illegible]	[illegible]	......	......	....	......	....	....
		Mean..	[illegible]							
*U. S. P. B. M. 23..	124.82	N.......	[illegible]	[illegible]	0.3	7.3	180.0110	+0.7	180.0117	....
		S.......	[illegible]	[illegible]	......	......	....	......	....	....
		Mean..	[illegible]							
*H. W. Mark, 1881, New Boston, Ill.	124.62	N.......	[illegible]	......	......	......	170.8588	......	....	....
T. B. M. 90........	124.77	N.......	[illegible]	0.9	0.6	......	167.4543	......	....	F.
		S.......	[illegible]	0.9	......	......	....	......	....	F.
		Mean..	[illegible]							
T. B. M. 91........	125.14	N.......	[illegible]	0.8	0.6	......	167.4345	......	....	(*)
		S.......	[illegible]		......	......	....	......	....	....
		N.......	[illegible]	0.9	......	......	....	......	....	....
		S.......	[illegible]		......	......	....	......	....	....
		Mean..	—0.0198							
T. B. M. 92 and 92*a*	125.23	N.......	+0.5673	—0.1	0.0	......	168.0017	......	....	P.
		S.......	+0.5672	0.0	......	......	....	......	....	P.
		Mean..	+0.5672							
T. B. M. 93........	126.31	N.......	+1.6575	—1.1	0.8	......	169.6581	......	....	P.
		S.......	+1.6562	+0.2	......	......	....	......	....	P.
		N.......	+1.6532	+3.2	......	......	....	......	....	F.
		S.......	+1.6588	—2.4	......	......	....	......	....	F.
		Mean..	+1.6564							
T. B. M. 94........	127.18	N.......	—1.5050	—0.5	0.2	......	168.1526	......	....	P.
		S.......	—1.5053	—0.2	......	......	....	......	....	P.
		N.......	—1.5061	+0.6	......	......	....	......	....	F.
		S.......	—1.5056	+0.1	......	......	....	......	....	F.
		Mean..	—1.5055							
T. B. M. 95........	128.40	N.......	+1.8817	+1.3	0.8	......	170.0356	......	....	P.
		N.......	+1.8803	+2.7	......	......	....	......	....	F.
		S.......	+1.8851	—2.1	......	......	....	......	....	P.
		S.......	+1.8851	—2.1	......	......	....	......	....	F.
		Mean..	+1.8830							
T. B. M. 96........	129.39	N.......	—1.0376	+0.6	0.4	......	168.9986	......	....	P.
		S.......	—1.0364	—0.6	......	......	....	......	....	P.
		Mean..	—1.0370							
T. B. M. 97........	130.31	N.......	+0.6427	—0.9	0.6	......	169.6404	......	....	P.
		S.......	+0.6410	+0.8	......	......	....	......	....	P.
		Mean..	+0.6418							

* Crossing New Boston Bay.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T.B.M. 98 and 98a	132.22	N.......	—0.0956	—1.4	0.9	......	169.5434	......	....	P.	F.
		S.......	—0.0984	+1.4	......	......	....	......	....	P.	F.
		Mean..	—0.0970								
T.B.M. 99.......	133.37	N.......	+1.1632	—0.4	0.3	......	170.7062	......	....	P.	F.
		S.......	+1.1624	+0.4	......	......	....	......	....	P.	F.
		Mean..	+1.1628								
T.B.M. 100.......	134.64	N.......	—0.5866	—0.6	0.4	......	170.1190	......	....	P.	J.
		S.......	—0.5877	+0.5	......	......	....	......	....	P.	J.
		Mean..	—0.5872								
T.B.M. 101.......	135.46	N.......	—0.6478	+0.9	0.6	......	169.4721	......	....	P.	J.
		S.......	—0.6460	—0.9	......	......	....	......	....	P.	J.
		Mean..	—0.6469								
T.B.M. 102.......	136.03	N.......	—0.2514	+2.0	0.6	......	169.2227	......	....	P.	F.
		S.......	—0.2470	—2.4	......	......	....	......	....	P.	F.
		N.......	—0.2493	—0.1	......	......	....	......	....	P.	F.
		S.......	—0.2501	+0.7	......	......	....	......	....	P.	F.
		Mean..	—0.2494								
T.B.M. 103.......	136.18	N.......	—0.3069	—0.5	0.4	......	168.9153	......	....	P.	F.
		S.......	—0.3080	+0.6	......	......	....	......	....	P.	F.
		Mean..	—0.3074								
T.B.M. 104.......	136.42	N.......	+0.0031	—0.2	0.1	......	168.9182	......	....	P.	J.
		S.......	+0.0027	+0.2	......	......	....	......	....	P.	J.
		Mean..	+0.0029								
T.B.M. 105.......	136.96	N.......	—0.0307	+0.4	0.3	......	168.9178	......	....	(*)	J.
		S.......	+0.0290		......	......	....	......	....	....	J.
		N.......	—0.0212	—0.5	......	......	....	......	....	....	F.
		S.......	+0.0214		......	......	....	......	....	....	F.
		Mean..	—0.0004								
T.B.M. 106.......	138.60	N.......	+2.1153	+4.0	1.1	......	171.0371	......	....	P.	J.
		S.......	+2.1231	—3.8	......	......	....	......	....	P.	J.
		N.......	+2.1188	+0.5	.....	......	....	......	....	P.	J.
		S.......	+2.1199	—0.6	......	......	....	......	....	P.	J.
		Mean..	+2.1193								
U.S.P.B.M. 24 = Mackenzie B.M. 46	138.62	S.......	+1.2697	+0.1	0.0	7.7	172.3069	+0.5	172.3074	....	J.
	....	S.......	+1.2698	0.0	......	......	....	......	....	....	F.
		Mean..	+1.2698								
T.B.M. 107.......	139.61	N	—1.1292	+4.2	1.0	......	169.9121	......	....	P.	J.
		S.......	—1.1232	—1.8	......	......	....	......	....	P.	J.
		N.......	—1.1250	0.0	......	......	....	......	....	P.	F.
		S.......	—1.1228	—2.2	......	......	....	......	....	P.	F.
		Mean..	—1.1250								
T.B.M. 108 and 108a.	141.24	N.......	—0.6700	+0.4	0.2	......	169.2425	......	....	P.	F.
		S.......	—0.6693	—0.3	......	......	....	......	....	P.	F.
		Mean..	—0.6696								
T.B.M. 109.......	142.86	N.......	+1.0217	—0.1	0.0	......	170.2641	......	....	P.	F.
		S.......	+1.0216	0.0	......	......	....	......	....	P.	F.
		Mean..	+1.0216								

* River crossing.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*H. W. Mark, 1881, Port Louisa, Iowa.	141.86	S	+1.0536				171.8177			P.	F.
T. B. M. 110	144.03	N	+0.3250	−2.9	1.1		170.5862			P.	J.
		S	+0.3194	+2.7						P.	J.
		N	+0.3218	+0.3						P.	J.
		Mean	+0.3221								
T. B. M. 111	145.71	N	+0.3540	−0.5	0.3		170.9397			P.	J.
		S	+0.3530	+0.5						P.	J.
		Mean	+0.3535								
T. B. M. 112	146.30	N	−0.3593	−1.8	1.2		170.5786			P.	F.
		S	−0.3629	+1.8						P.	F.
		Mean	−0.3611								
T. B. M. 113	146.98	N	+0.4048	+0.1	0.1		170.9835			P.	F.
		S	+0.4050	−0.1						P.	F.
		Mean	+0.4049								
T. B. M. 114 and 114*a*.	147.81	N	+1.3335	−1.5	1.0		172.3155			P.	F.
		S	+1.3306	+1.4						P.	F.
		Mean	+1.3320								
T. B. M. 115	148.80	N	+0.2448	−3.2	1.1		172.5571			P.	F.
		S	+0.2398	+1.8						P.	F.
		N	+0.2401	+1.5						P.	F.
		Mean	+0.2416								
T. B. M. 116	149.32	N	−1.0220	−0.6	0.4		171.5345			P.	F.
		S	−1.0231	+0.5						P.	F.
		Mean	−1.0226								
T. B. M. 117	150.72	N	+0.0247	−1.1	0.7		171.5581			P.	J.
		S	+0.0225	+1.1						P.	J.
		Mean	+0.0236								
*U. S. P. B. M. 25	150.85	S	+0.4415	+0.9	0.6	8.1	172.0005	+0.5	172.0010	P.	J.
		N	+0.4434	−1.0						P.	F.
		Mean	+0.4424								
*H. W. Mark, June, 1880.	150.85	N	+0.3606				171.9187				F.
*H. W. Mark, 1851	150.90	N	+0.0010				172.0015				F.
*H. W. Mark, Oct., 1881.	150.90	N	−0.0157				171.9848				F.
T. B. M. 118	151.65	N	+1.5861	+1.9	1.3		173.1461			P.	J.
		S	+1.5899	−1.9						P.	J.
		Mean	+1.5880								
*U. S. P. B. M. 26	151.68	N	+0.1078			8.2	173.2539	+0.5	173.2544		J.
T. B. M. 119	152.95	N	−1.8469	−0.5	0.3		171.2987			P.	J.
		S	−1.8478	+0.4						P.	J.
		Mean	−1.8474								
T. B. M. 120 and 120*a*.	154.62	N	+0.9804	−0.6	0.4		172.2785			P.	F.
		S	+0.9791	+0.7						P.	F.
		Mean	+0.9798								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 121	155. 27	N	−2. 5495	+1. 0	0. 7	....	169. 7300	....	....	P.	F.
		S	−2. 5475	−1. 0	....	....	....	....	....	P.	F.
		Mean..	−2. 5485								
T. B. M. 122	156. 49	N	+0. 8871	+1. 7	1. 1	....	170. 6188	....	....	P.	F.
		S	+0. 8904	−1. 6	....	....	....	....	....	P.	F.
		Mean..	+0. 8888								
T. B. M. 123	157. 79	N	+2. 0076	0. 0	0. 0	....	172. 6264	....	....	P.	F.
		S	+2. 0077	−0. 1	....	....	....	....	....	P.	F.
		Mean..	+2. 0076								
T. B. M. 124	158. 36	N	+0. 1844	+0. 2	0. 1	....	172. 8110	....	....	P.	J.
		S	+0. 1848	−0. 2	....	....	....	....	....	P.	J.
		Mean..	+0. 1846								
T. B. M. 125	159. 31	N	+0. 0818	+1. 1	0. 7	....	172, 8939	....	....	P.	J.
		S	+0. 0840	−1. 1	....	....	....	....	....	P.	J.
		Mean..	+0. 0829								
*H. W. M., Apr. 2[illegible], 1870, 2½ miles below Muscatine, Iowa.	159. 36	N	−0. 3710	....	....	....	172. 5229	....	....	....	J.
*H. W. M., June 2[illegible], 1880.	159. 36	N	−0. 1720	....	....	....	172. 7219	....	....	....	J.
*H. W. M., Oct., 1881.	159. 36	N	−0. 1350	....	....	....	172. 7589	....	....	....	J.
T. B. M. 126	160. 23	N	−1. 0263	+1. 1	0. 7	....	171. 8687	....	....	P.	J.
		S	−1. 0241	−1. 1	....	....	....	....	....	P.	J.
		Mean..	−1. 0252								
T. B. M. 127 and 127a.	160. 86	N	−0. 1105	−0. 5	0. 4	....	171. 7577	....	....	P.	J.
		S	−0. 1116	+0. 6	....	....	....	....	....	P.	J.
		Mean..	−0. 1110								
*U. S. P. B. M. 27 .	161. 08	N	+2. 0790	−0. 1	0. 1	8. 4	173, 8366	+0. 5	173. 8371	P.	J.
		S	+2. 0788	+0. 1	....	....	....	....	....	P.	J.
		Mean..	+2. 0789								
T. B. M. 128 and 128a.	163. 04	N	+1. 3444	−1. 2	0. 8	....	173. 1009	....	....	P.	J.
		S	+1. 3419	+1. 3	....	....	....	....	....	P.	J.
		Mean..	+1. 3432								
*H. W. M., June, 1880, Muscatine, Iowa.	163. 10	N	−0. 0277	....	....	....	173. 0732	....	....	....	J.
*H. W. M., Oct., 1881.	163. 10	N	−0. 0027	....	....	....	173. 0982	....	....	....	J.
T. B. M. 129	164. 06	N	+0. 0176	−1. 6	1. 1	....	173. 1169	....	....	P.	F.
		S	+0. 0144	+1. 6	....	....	....	....	....	P.	F.
		Mean..	+0. 0160								
*U. S. P. B. M. 28 .	164. 08	N	+1. 1794	0. 0	0. 0	8. 5	174. 2963	+0. 5	174. 2968	....	F.
		S	+1. 1794	0. 0	....	....	....	....	....	....	F.
		Mean..	+1. 1794								
*P. B. M. 44, Mackenzie.	164. 12	N	+0. 2029	+0. 1	0. 1	8. 5	173. 3199	+0. 5	173. 3204	....	F.
		S	+0. 2031	−0. 1	....	....	....	....	....	....	F.
		Mean..	+0. 2030								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*16 ft. mark in well of water works, Muscatine, Iowa.	164.15	N	—0.6287	—0.1	0.1	......	172.6911	......	....	...	F.
		S.......	—0.6290	+0.2	......	......	....	......	....	...	F.
		Mean..	—0.6288								
*H. W. M., Oct., 1881, Muscatine, Iowa.	164.14	N	—0.0129	+0.3	0.2	......	173.1043	......	....	...	F.
		S.......	—0.0122	—0.4	......	......	....	......	....	...	F.
		Mean..	—0.0126								
U. S. P. B. M. 29...	164.35	N	[illegible]	[illegible]	[illegible]	8.5	174.4344	+0.5	174.4349	P.	F.
		S.......	[illegible]	[illegible]	......	......	....	......	....	P.	F.
		Mean..	[illegible]								
T. B. M. 130 and 130*a*.	165.44	N	[illegible]	[illegible]	[illegible]	......	173.5362	......	....	P.	F.
		S.......	[illegible]	[illegible]	......	......	....	......	....	P.	F.
		Mean..	[illegible]								
T. B. M. 131 and 131*a*.	166.99	N	[illegible]	[illegible]	[illegible]	......	173.5986	......	....	P.	F.
		S.......	[illegible]	[illegible]	......	......	....	......	....	P.	F.
		Mean..	[illegible]								
T. B. M. 132 and 132*a*.	168.84	N	[illegible]	[illegible]	[illegible]	......	173.8320	......	....	P.	J.
		S.......	[illegible]	[illegible]	......	......	....	......	....	P.	J.
		Mean..	[illegible]								
*U. S. P. B. M. 30.	169.47	N	[illegible]	......	......	8.7	174.7930	+0.5	174.7935	P.	J.
T. B. M. 133 and 133*a*.	170.10	N	+1.5424	—1.8	1.2	......	175.3726	......	....	P.	J.
		S.......	+1.5389	+1.7	......	......	....	......	....	P.	J.
		Mean..	+1.5406								
T. B. M. 134 and 134*a*.	171.58	N	+0.3503	+1.5	1.0	......	175.7244	......	....	P.	F.
		S.......	+0.3534	—1.6	......	......	....	......	....	P.	F.
		Mean..	+0.3518								
U. S. P. B. M. 31 ..	172.65	N	—1.1705	+0.3	0.2	8.8	174.5542	+0.5	174.5547	P.	F.
		S.......	—1.1699	—0.3	......	......	....	......	....	P.	F.
		Mean..	+1.1702								
T. B. M. 135.......	173.66	N	+1.3195	—0.8	0.5	......	175.8729	......	....	P.	F.
		S.......	+1.3179	+0.8	......	......	....	......	....	P.	F.
		Mean..	+1.3187								
*U. S. P. B. M. 32.	173.68	N	+1.3146	......	......	8.8	177.1875	+0.6	177.1881	...	J.
T. B. M. 136.......	174.15	N	+0.3607	—1.3	0.8	......	176.2323	......	....	P.	F.
		S.......	+0.3582	+1.2	......	......	....	......	....	P.	F.
		Mean..	+0.3594								
T. B. M. 137 and 137*a*.	175.50	N	+0.4745	—0.7	0.4	......	177.7061	......	....	P.	J.
		S.......	+1.4732	+0.6	......	......	....	......	....	P.	J.
		Mean..	+1.4738								
T. B. M. 138 and 138*a*.	176.72	N	—0.5076	+0.3	0.2	......	177.1988	......	....	P.	J.
		S.......	—0.5070	—0.3	......	......	....	......	....	P.	J.
		Mean..	—0.5073								
*U. S. P. B. M. 33.	176.96	N	—1.8109	+0.7	0.4	8.9	175.3886	+0.5	175.3891	P.	F.
		S.......	—1.8096	—0.6	......	......	....	......	....	P.	F.
		Mean..	—1.8102								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.		
*P. B. M. 43, Mackenzie.	177.24	N	−1.0170	......	......	8.9	176.1818	+0.6	176.1824	F.	J.
*Mackenzie, B. M., on Elm Tree, Fairport, Iowa.	177.36	N	−3.8621	+1.3	0.9	......	173.3380	+0.5	173.3385	F.	J.
		S	−3.8594	−1.4	......	......	....	......	....	F.	J.
		Mean ..	−3.8608								
T. B. M. 139 and 139a.	178.21	N	−0.8628	+0.3	0.2	......	176.3363	......	....	F.	J.
		S	−0.8622	−0.3	......	......	....	......	....	F.	J.
		Mean ..	−0.8625								
T. B. M. 140 and 140a.	179.59	N	+0.6706	−0.8	0.5	......	177.0061	......	....	F.	F.
		S	+0.6690	+0.8	......	......	....	......	....	F.	F.
		Mean ..	+0.6698								
T. B. M. 141 and 141a.	180.65	N	−1.3952	+1.2	0.8	......	175.6121	......	....	F.	F.
		S	−1.3928	−1.2	......	......	....	......	....	F.	F.
		Mean ..	−1.3940								
U. S. P. B. M. 34...	181.31	N	−0.5133	+0.5	0.3	8.9	175.0993	+0.5	175.0998	F.	J.
		S	−0.5123	−0.5	......	......	....	......	....	F.	J.
		Mean ..	−0.5128								
T. B. M. 142 and 142a.	181.98	N	+1.2352	−0.2	0.2	......	176.3343	......	....	F.	J.
		S	+1.2347	+0.3	......	......	....	......	....	F.	J.
		Mean ..	+1.2350								
T. B. M. 143 and 143a.	183.18	N	+0.2463	+3.8	0.9	......	176.5844	......	....	F.	J.
		S	+0.2527	−2.6	......	......	....	......	....	F.	J.
		N	+0.2512	−1.1	......	......	....	......	....	F.	J.
		S	+0.2501	0.0	......	......	....	......	....	F.	J.
		Mean ..	+0.2501								
T. B. M. 144 and 144a.	184.32	N	+1.8869	+4.0	0.7	......	178.4753	......	....	F.	F.
		S	+1.8922	−1.3	......	......	....	......	....	F.	F.
		N	+1.8918	−0.9	......	......	....	......	....	F.	F.
		S	+1.8927	−1.8	......	......	....	......	....	F.	F.
		N	+1.8909	0.0	......	......	....	......	....	F.	F.
		Mean ..	+1.8909								
T. B. M. 145.......	185.01	N	−0.2702	0.0	0.0	......	178.2051	......	....	F.	F.
		S	−0.2701	−0.1	......	......	....	......	....	F.	F.
		Mean ..	−0.2702								
*U. S. P. B. M. 35..	185.18	N	+0.0050	+0.4	0.2	9.0	178.2105	+0.6	178.2111	....	F.
		S	+0.0057	−0.3	......	......	....	......	....	....	F.
		Mean ..	+0.0054								
T. B. M. 146.......	186.07	N	−0.6355	−1.7	1.2	......	177.5679	......	....	F.	F.
		S	−0.6390	+1.8	......	......	....	......	....	F.	F.
		Mean ..	−0.6372								
U. S. P. B. M. 35A.	186.95	N	−1.6454	+0.2	0.1	9.1	175.9227	+0.6	175.9233	F.	J.
		S	−1.6451	−0.1	......	......	....	......	....	F.	J.
		Mean ..	−1.6452								
T. B. M. 147 and 147a.	187.43	N	+0.2814	+0.7	0.5	......	176.2048	......	....	F.	J.
		S	+0.2828	−0.7	......	......	....	......	....	F.	J.
		Mean ..	+0.2821								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 148 and 148*a*.	188.12	N.......	+2.2801	—1.5	1.0	......	178.4864	......	....	F.
		S.......	+2.2830	+1.4	......	......	....	......	....	F.
		Mean ..	+2.2816							
T. B. M. 149 and 149*a*.	188.86	N.......	+0.2240	—0.2	0.1	......	178.7102	......	....	F.
		S.......	+0.2236	+0.2	......	......	....	......	....	F.
		Mean ..	+0.2238							
T. B. M. 150 and 150*a*.	190.18	N.......	+1.1952	0.0	0.0	......	179.9054	......	....	F.
		S.......	+1.1951	+0.1	......	......	....	......	....	F.
		Mean ..	+1.1952							
T. B. M. 151 and 151*a*.	190.69	N.......	—0.6553	+0.3	0.2	......	179.2504	......	....	F.
		S.......	—0.6546	—0.4	......	......	....	......	....	F.
		Mean ..	—0.6550							
T. B. M. 152 and 152*a*.	192.10	N.......	—3.4540	—0.6	0.4	......	175.7958	......	....	F.
		S.......	—3.4553	+0.7	......	......	....	......	....	F.
		Mean ..	—3.4546							
T. B. M. 153.......	192.43	N.......	—0.0522	—0.1	0.1	......	175.7435	......	....	F.
		S.......	—0.0524	+0.1	......	......	....	......	....	F.
		Mean ..	—0.0523							
T. B. M. 154.......	192.93	N.......	+0.1140	+2.5	0.6	......	175.8600	......	....	F.
		S.......	+0.1182	—1.7	......	......	....	......	....	F.
		N.......	+0.1162	+0.8	......	......	....	......	....	F.
		S.......	+0.1177	—1.2	......	......	....	......	....	F.
		Mean ..	+0.1165							
*U. S. P. B. M. 36..	193.12	N.......	+2.5400	0.0	0.0	9.2	178.4000	+0.6	178.4006	F.
		S.......	+2.5399	+0.1	......	......	....	......	....	F.
		Mean ..	+2.5400							
T. B. M. 155 and 155*a*.	193.49	N.......	+0.0378	+0.2	0.1	......	175.8980	......	....	F.
		S.......	+0.0381	—0.1	......	......	....	......	....	F.
		Mean ..	+0.0380							
T. B. M. 156.......	194.45	N.......	+0.5318	+3.4	1.0	......	176.4332	......	....	F.
		S.......	+0.5379	—2.7	......	......	....	......	....	F.
		N.......	+0.5372	—2.0	......	......	....	......	....	F.
		S.......	+0.5341	+1.1	......	......	....	......	....	F.
		Mean ..	+0.5352							
*U. S. P. B. M. 37..	194.52	N.......	+3.0326	+0.4	0.2	9.2	179.4662	+0.7	179.4669	...
		S.......	+3.0333	—0.3	......	......	....	......	....	...
		Mean ..	+3.0330							
T. B. M. 157 and 157*a*.	195.10	N.......	+0.6062	+1.0	0.7	......	177.0404	......	....	F
		S.......	+0.6083	—1.1	......	......	....	......	....	F
		Mean ..	+0.6072							
T. B. M. 158.......	196.06	N.......	+0.9624	+1.8	0.9	......	178.0041	......	....	F
		S.......	+0.9650	—1.8	......	......	....	......	....	F
		Mean ..	+0.9637							

***Results of precise leveling*—Continued.**

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
M. 159 and	196.69	N.......	+0.2235	+1.7	0.5	......	178.2293	......	....	F.	F.
		S	+0.2268	−1.6	......	......	....	......	....	F.	F.
		N.......	+0.2259	−0.7	......	......	....	......	....	F.	F.
		S	+0.2248	+0.4	......	......	....	......	....	F.	F.
		Mean..	+0.2252								
M. 160 and	196.93	N.......	+1.0638	+1.3	0.4	......	179.2944	......	....	F.	F.
		S	+1.0664	−1.3	......	......	....	......	....	F.	F.
		N.......	+1.0650	+0.1	......	......	....	......	....	F.	F.
		S	+1.0652	−0.1	......	......	....	......	....	F.	J.
		Mean..	+1.0651								
L. 161 and	198.33	N.......	−0.2918	−1.8	1.2	......	179.0008	......	....	F.	J.
		S	−0.2953	+1.7	......	......	....	......	....	F.	J.
		Mean..	−0.2936								
. 162.......	199.46	N.......	−2.3250	−4.2	1.1	......	176.6716	......	....	F.	J.
		S	−2.3325	+3.3	......	......	....	......	....	F.	J.
		N.......	−2.3290	−0.2	......	......	....	......	....	F.	J.
		S	−2.3303	+1.1	......	......	....	......	....	F.	J.
		Mean..	−2.3292								
L. 163 and	200.48	N.......	+0.2766	−2.2	1.5	......	176.9460	......	....	F.	J.
		S	+0.2721	+2.3	......	......	....	......	....	F.	J.
		Mean..	+0.2744								
. 164.......	201.66	N.......	+1.3340	+1.2	0.8	......	178.2812	......	....	F.	F.
		S	+1.3365	−1.3	......	......	....	......	....	F.	F.
		Mean..	+1.3352								
L. 165.......	202.88	N.......	−1.6418	−0.2	0.1	......	176.6392	......	....	F.	F.
		S	−1.6422	+0.2	......	......	....	......	....	F.	F.
		Mean..	−1.6420								
M. 166 and	204.15	N.......	+0.2903	−2.9	0.9	.....	176.9266	......	....	F.	F.
		S	+0.2839	+3.5	......	......	....	......	....	F.	F.
		N.......	+0.2876	−0.2	......	......	....	......	....	F.	F.
		S	+0.2878	−0.4	......	......	....	......	....	F.	F.
		Mean..	+0.2874								
M. 168 and	205.70	N.......	+0.4104	+0.4	0.3	......	177.3374	......	....	F.	J.
		S	+0.4112	+0.4	......	......	....	......	....	F.	J.
		Mean..	+0.4108								
P. B. M. 38..	205.77	N.......	+1.6909	+0.1	0.1	9.7	179.0284	+0.7	179.0291	....	F.
		S	+1.6912	−0.2	......	......	....	......	....	....	F.
		Mean..	+1.6910								
M. 170 and	206.78	N.......	+0.6767	−0.1	0.1	......	178.0140	......	....	F.	J.
		S	+0.6764	+0.2	......	......	....	......	....	F.	J.
		Mean..	+0.6766								
M. 171 and	208.17	N.......	+1.7992	−0.8	0.5	......	179.8124	......	....	F.	F.
		S	+1.7976	+0.8	......	......	....	......	....	F.	F.
		Mean..	+1.7984								
M. 172 and	208.99	N.......	+1.0681	−0.3	0.2	......	180.8802	.....	....	F.	F
		S	+1.0676	+0.2	......	......	....	......	....	F.	F
		Mean..	+1.0678								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observ[er].
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*U. S. P. B. M. 39	208.02	N	−0.0061	+0.1	0.1	9.7	180.8742	+0.7	180.8749	....	F
		S	−0.0059	−0.1						....	F
		Mean	−0.0060								
T. B. M. 173	208.69	N	−1.4397	−0.5	0.3	......	179.4400	......	....	F.	J
		S	−1.4407	+0.5						F.	J
		Mean	−1.4402								
*Zero of gauge at Rock Island Bridge.	208.96	N	−8.0315	......	......	......	171.4085	......	....	....	J
*U. S. P. B. M. 40	208.80	N	+2.6728	+0.4	0.2	9.7	182.1132	+0.7	182.1139	....	
		S	+2.6735	−0.3						....	
		Mean	+2.6732								
*Astronomical post, Rock Island.	210.07	N	−0.4291	+0.1	0.1	......	179.0010	+0.7	179.0017	....	
		S	−0.4288	−0.2						....	
		Mean	−0.4290								
*H. W., 1880	209.96	N	−2.4233	......	......	......	177.0167	......	....	....	
T. B. M. 175	211.02	N	+0.6892	−1.3	0.9	......	180.1279	......	....	F.	
		S	+0.6866	+1.3						F.	
		Mean	+0.6879								
*U. S. P. B. M. 41	211.86	N	+3.1766	0.0	0.0	9.7	183.3045	+0.8	183.3053	....	
		S	+3.1767	−0.1						....	
		Mean	+3.1766								
T. B. M. 176 and 176a.	213.51	N	+1.5206	0.0	0.0	......	181.6485	......	....	F.	
		S	+1.5207	−0.1						F.	
		Mean	+1.5206								
T. B. M. 177	214.36	N	−1.3763	+1.9	1.2	......	180.2741	......	....	F.	
		S	−1.3726	−1.8						F.	
		Mean	−1.3744								
*U. S. P. B. M. 42	214.55	N	−0.7034	−0.6	0.4	9.6	179.5701	+0.7	179.5708	....	
		S	−0.7046	+0.6						....	
		Mean	−0.7040								
T. B. M. 178	215.15	N	+0.5246	+0.4	0.2	......	180.7991	......	....	F.	
		S	+0.5253	−0.3						F.	
		Mean	+0.5250								
T. B. M. 179	216.22	N	+0.1589	+1.6	1.1	......	180.9596	......	....	F.	
		S	+0.1621	−1.6						F.	
		Mean	+0.1605								
T. B. M. 180	217.28	N	+0.3918	−2.0	1.3	......	181.3494	......	....	F.	
		S	+0.3879	+1.9						F.	
		Mean	+0.3898								
T. B. M. 181	218.27	N	−1.4885	−0.1	0.0	......	179.8608	......	....	P.	
		S	−1.4886	0.0						P.	
		Mean	−1.4886								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		M.	Mm.	Mm.	Mm.	M.	Mm.	M.		
T. B. M. 182	219.27	N	+1.2212	—0.7	0.5		181.0813			P.	J.
		S	+1.2198	+0.7						P.	J.
		Mean	+1.2205								
T. B. M. 183	220.17	N	+0.8765	+4.2	0.7		181.9620			F.	F.
		S	+0.8794	+1.3						F.	F.
		N	+0.8815	—0.8						F.	F.
		S	+0.8847	—4.0						F.	F.
		N	+0.8813	—0.6						P.	F.
		S	+0.8808	—0.1						P.	F.
		Mean	+0.8807								
T. B. M. 184 and 184a.	221.45	N	—1.6218	+4.1	1.1		180.3443			F.	F.
		S	—1.6169	—0.8						F.	F.
		N	—1.6142	—3.5						P.	F.
		S	—1.6179	+0.2						P.	F.
		Mean	—1.6177								
T. B. M. 185	222.34	N	—1.3258	—0.7	0.5		179.0178			P.	J.
		S	—1.3272	+0.7						P.	F.
		Mean	—1.3265								
T. B. M. 186 and 186a.	223.17	N	—0.2976	+0.2	0.1		178.7204			P.	J.
		S	—0.2973	—0.1						P.	J.
		Mean	—0.2974								
*U. S. P. B. M. 43	223.28	N	+2.7073	—0.1	0.0	10.1	181.4276	+0.7	181.4283	P.	J.
		S	+2.7072	0.0						P.	J.
		Mean	+2.7072								
T. B. M. 187	224.40	N	+2.3087	—0.3	0.2		181.0288			P.	J.
		S	+2.3081	+0.3						P.	J.
		Mean	+2.3084								
T. B. M. 188 and 188a.	225.12	N	+1.3826	—1.0	0.7		182.4104			P.	J.
		S	+1.3806	+1.0						P.	J.
		Mean	+1.3816								
*U. S. P. B. M. 44	225.93	N	—0.5884	—0.8	0.5	10.1	182.9980	+0.8	182.9988	P.	F.
		S	+0.5869	+0.7						P.	F.
		Mean	+0.5876								
T. B. M. 189 and 189a.	225.98	N	+0.1590	—1.0	0.6		182.5684			P.	F.
		S	+0.1571	+0.9						P.	F.
		Mean	+0.1580								
*U. S. P. B. M. 45. H. W., June, 1880.	226.51	N	—2.6251	—0.3	0.2	10.1	179.9430	+0.7	179.9437	P.	J.
		S	—2.6257	+0.3						P.	J.
		Mean	—2.6254								
T. B. M. 190 and 190a.	227.21	N	+1.6610	—2.1	1.4		184.2273			P.	F.
		S	+1.6568	+2.1						P.	F.
		Mean	+1.6589								
T. B. M. 191 and 191a.	228.46	N	—0.9600	—2.4	1.6		183.2649			P.	J.
		S	—0.9647	+2.3						P.	J.
		Mean	—0.9624								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 192 and 192a.	230.37	N	+0.0750	—1.0	0.7		183.3389			P.	J.
		S	+0.0729	+1.1						P.	J.
		Mean	+0.0740								
T. B. M. 192A	232.47	N	+1.5033	+0.9	0.6		184.8431			P.	F.
		S	+1.5051	—0.9						P.	F.
		Mean	+1.5042								
*U. S. P. B. M. 46	232.66	N	—3.0028	+0.5	[illegible]	10.4	181.8408	+0.8	181.8416	P.	J.
		S	—3.0018	—0.5						P.	J.
		Mean	—3.0023								
T. B. M. 193 and 193a.	233.21	N	—0.5128	+0.8	0.5		184.3311			P.	F.
		S	—0.5113	—0.7						P.	F.
		Mean	—0.5120								
T. B. M. 194	234.07	N	—1.3869	—1.4	0.9		182.9428			P.	J.
		S	—1.3897	+1.4						P.	J.
		Mean	—1.3883								
*U. S. P. B. M. 47	234.24	N	+0.0077	0.0	0.0	10.4	182.9505	+0.8	182.9513		J.
		S	+0.0077	0.0							J.
		Mean	+0.0077								
T. B. M. 195	235.46	N	+0.0988	0.0	0.0		183.0416			P.	J.
		S	+0.0989	—0.1						P.	J.
		Mean	+0.0988								
*U. S. P. B. M. 48	235.47	N	+0.3589			10.4	183.4005	+0.8	183.4013		J.
*P. B. M. 40, Mackenzie.	235.52	N	—0.4690				182.5726	+0.8	182.5734		J.
*U. S. P. B. M. 49	235.66	N	+2.1609			10.4	185.2025	+0.8	185.2033		F.
*H. W., June 25, 1880.	235.62	N	—0.8818				182.1598				F.
*H. W., Oct., 1881	235.62	N	—1.0596				181.9820				F.
T. B. M. 196 and 196a.	238.34	N	+2.4776	+1.6	1.1		185.5208			P.	F.
		S	+2.4808	—1.6						P.	F.
		Mean	+2.4792								
T. B. M. 197	239.71	N	+3.1306	—5.0	0.8		188.6464			P.	F.
		S	+3.1219	+3.7						P.	F.
		N	+3.1265	—0.9						F.	F.
		S	+3.1263	—0.7						F.	F.
		N	+3.1244	+1.2						P.	F.
		S	+3.1242	+1.4						P.	F.
		Mean	+3.1256								
T. B. M. 198 and 198a.	241.35	N	+1.1282	—2.1	1.4		189.7725			P.	F.
		S	+1.1240	+2.1						P.	F.
		Mean	+1.1261								
T. B. M. 199	242.60	N	—2.4735	—0.3	0.2		187.2987			P.	J.
		S	—2.4740	+0.2						P.	J.
		Mean	—2.4738								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

nch.	Distance.	Direction.	Difference of elevation.	v.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
290	243.76	N	−0.5731	−0.5	0.3		186.7251			P.	J.
		S	−0.5740	+0.4						P.	J.
		Mean	−0.5736								
B. M. 50.	244.66	N	−5.6715	+0.1	0.1	10.6	181.0537	+0.7	181.0544	P.	F.
		S	−5.6712	−0.2						P.	F.
		Mean	−5.6714								
L 39, Mac-a.		N	+0.0154			10.6	181.0691	+0.7	181.0698		F.
1870		N	+2.0336				183.0873				F.
B. M. 51	244.13	N	+0.7885			10.6	187.5136	+0.9	187.5145		J.
L 201 and	244.59	N	+2.4419	+0.7	0.4		189.1677			P.	J.
		S	+2.4432	−0.6						P.	J.
		Mean	+2.4426								
L 202 and	246.58	N	+0.6109	−1.6	1.1		189.7770			F.	J.
		S	+0.6077	+1.6						F.	J.
		Mean	+0.6093								
L 203 and	247.58	N	+0.4328	+0.2	0.1		190.2100			F.	J.
		S	+0.4332	−0.2						F.	J.
		Mean	+0.4330								
L 204 and	248.59	N	+0.9696	+1.3	0.9		191.1809			F.	F.
		S	+0.9722	−1.3						F.	F.
		Mean	+0.9709								
L 205	249.44	N	+1.2849	−0.5	0.3		192.4653			F.	F.
		S	+1.2839	+0.5						F.	F.
		Mean	+1.2844								
M. 206 and	251.41	N	−0.0492	+0.6	0.4		192.4167			F.	F.
		S	−0.0481	−0.5						F.	F.
		Mean	−0.0486								
L 207	252.79	N	−3.0692	−1.8	1.2		189.3457			F.	J.
		S	−3.0729	+1.9						F.	J.
		Mean	−3.0710								
M. 208 and	254.24	N	−1.6983	−0.5	0.3		187.6469			F.	J.
		S	−1.6993	+0.5						F.	J.
		Mean	−1.6988								
63, Henne-Canal.	256.27	N	−4.9627	−0.7	0.4	10.8	182.6835	+0.8	182.6843	F.	J.
		S	−4.9640	+0.6						F.	J.
		Mean	−4.9634								
64, Henne-Canal.	256.32	N	−0.0691	+0.1	0.1	10.8	182.6145	+0.8	182.6153	F.	J.
		S	−0.0688	−0.2						F.	J.
		Mean	−0.0690								
L 209 and	258.53	N	+2.3604	−0.4	0.3		185.0435			F.	F.
		S	+2.3596	+0.4						F.	F.
		Mean	+2.3600								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 210	259.57	N	−1.7114	+0.6	0.4	.....	183.3327	......	....	F.	F.
		S	−1.7101	−0.7	......	......	....	......	....	F.	F.
		Mean ..	−1.7108								
*U. S. P. B. M. 52 .	260.57	N	+4.3659	−0.5	0.3	10.8	187.6981	+0.9	187.6990	F.	F.
		S	+4.3650	+0.4	......	......	....	......	....	F.	F.
		Mean ..	[illegible]								
*P. B. M. 37, Mackenzie.	....	N ...	[illegible]	[illegible]	[illegible]	10.8	184.5199	+0.8	184.5207	....	F.
*H. W., 1870	....	N ...	[illegible]	[illegible]	[illegible]	......	184.2672	......	....	....	F.
*H. W., 1880	....	N	[illegible]	[illegible]	[illegible]	......	184.4259	......	....	....	F.
T. B. M. 211 and 211*a*.	260.22	N	[illegible]	[illegible]	[illegible]	......	183.7434	......	....	F.	F.
		S	[illegible]	[illegible]	[illegible]	......	....	......	....	F.	F.
		Mean ..	[illegible]								
T. B. M. 212	261.22	N	[illegible]	[illegible]	[illegible]	......	184.8800	......	....	F.	J.
		S	[illegible]	[illegible]	[illegible]	......	....	......	....	F.	J.
		Mean	[illegible]								
*U. S. P. B. M. 53 .	261.29	N	[illegible]	[illegible]	[illegible]	......	188.6000	+0.9	188.6009	F.	J.
		S	[illegible]	[illegible]	[illegible]	......	....	......	....	F.	J.
		Mean ..	[illegible]								
T. B. M. 213 and 213*a*.	262.24	N	−0.7[illegible]	−3.4	1.0	......	184.1420	......	....	F.	J.
		S	−0.7417	+3.7	......	......	....	......	....	F.	J.
		N	−0.7377	−0.3	......	......	....	......	....	F.	J.
		S	−0.7379	−0.1	......	......	....	......	....	F.	J.
		Mean ..	−0.7380								
U. S. P. B. M. 54 ..	263.33	N	−1.8437	+0.5	0.4	10.9	182.2988	+0.7	182.2995	P.	F.
		S	−1.8426	−0.6	......	......	....	......	....	P.	F.
		Mean ..	−1.8432								
T. B. M. 214 and 214*a*.	265.22	N	+3.4398	+0.5	0.3	......	185.7391	......	....	P.	F.
		S	+3.4408	−0.5	......	......	....	......	....	P.	F.
		Mean ..	+3.4403								
U. S. P. B. M. 55 ..	266.94	N	−2.4423	+0.3	0.2	11.0	183.2971	+0.7	183.2978	P.	F.
		S	−2.4418	−0.2	......	......	....	......	....	P.	F.
		Mean ..	−2.4420								
U. S. P. B. M. 56 ..	266.99	N	+0.3828	+0.2	0.1	11.0	183.6801	+0.8	183.6809	....	F.
		S	+0.3832	−0.2	......	......	....	......	....	....	F.
		Mean ..	+0.3830								

DESCRIPTION OF PERMANENT BENCH-MARKS BETWEEN CARROLLTON, LA., AND BILOXI MISS.

U. S. C. S. B. M. No. 1 is a small cross (+) cut on iron sill of walled-up door, near northwest corner of seventh district Babcock engine-house, Carrollton, La. Elevation, 9m.0272.

HAMPSON BENCH (WILLIAMS).—The old Hampson Bench is a spike in N. W. corner of N. O. and C. R. R. machine-shop at Carrollton, La. It is between the 19th and 20th courses of bricks below the window-sill, and about six inches (6″) below the surface of the ground. Elevation, 8m.8292.

HAMPSON BENCH (*Re-established by Major Howell*) is a spike in the N. W. corner of N. O. and C. R. R. machine-shop at Carrollton, La. It is between the 21st and 22d courses of brick below the window-sill. Elevation, 8m.6551.

B. M. 3 (*Ripley*, 1875) is the top of a broken spike driven into the north face of the car-house of the N. O. and C. R. R. It is two feet (2′) west of west side of door, on a level with the course of bricks upon which the door-sill rests. Elevation, 9m.7752.

B. M. 4 (*Ripley*, 1875) is the top of a ship-spike driven in the north side of the machine-shop of the N. O. and C. R. R., 0.2 ft. from N. W. corner. The spike is driven between the bricks, 37 courses from top of window casing. Elevation, 9m.5181.

B. M. 5 (*Burney*, 1875), is mark ^ U. S. E. cut on the west end of iron sill of the north door of the N. O. and C. R. R. depot. Elevation 9m.0303.

U. S. P. B. M. "CARROLLTON" is the center of small hole in center of copper bolt, leaded horizontally in north face of masonry of northwest corner pillar of old court-house, at Carrollton, La. The bolt is in the middle, about 0.03 ft. from water table of pillar and about 2.5 ft. above the ground. The letters U S ⊙ P B M are cut near the bolt. Elevation, 9m.1478.

CITY B. M. x x STONE is top of granite marking stone set in ground, in line of trees, on the west side of Carrollton ave., about half-way between 3d st. and Zimple st., Carrollton, La., The stone is marked thus:

X X M B JUNE + 1874.

The mark + denotes the point where the rod was held. Elevation, 7m.7655.

CITY STONE (*corner Washington and Carrollton avenues*). This stone is set at southeast corner of crossing of Washington and Carrollton avenues, near New Orleans, La. Elevation, 7m.7633.

U. S. P. B. M. 1 is a copper bolt leaded vertically in the top of the northwest portion of draw-pier of bridge, called the "White Bridge," crossing the new canal, on the Carrollton road, near New Orleans, La. Elevation, 6m.9402.

City Stone "Halfway House" is a granite marking-stone set in ground on west side of navigable canal (New Basin), near Metairie Ridge Bridge, between the Halfway House and the gate to Metairie Cemetery. It is said to be the line-stone of the Orleans and Metairie Parishes of New Orleans, La. The stone is marked on top with a cross. Elevation, 7m.9870.

Bench-mark "Height of Metairie Ridge" is a granite marking-stone set in ground 12 ft. southeast from southeast abutment of Lake Bridge, on east side of canal (New Basin). The bridge crosses the canal (New Basin) opposite Toney's House, West End, near New Orleans, La. The top of the stone is 8″ x 13″, and is marked

BENCHMARK HEIGHT OF METAIRIE RIDGE.

Elevation, 7m.6753.

Bench-mark (near Lake House, West End, La.). This bench-mark is the top of a stone, set in ground between the Lake House and Toney's House. It is on line with front fence of Toney's House, 160 ft. from center of canal and about 30 ft. from road, crossing the canal on the Lake Bridge, at West End, near New Orleans, La. Elevation, 7m.1244.

U. S. P. B. M. 2 is the center of a copper bolt leaded horizontally in the northwest face of the south one of two brick abutments, at northwest end of draw-bridge across the Bayou St. John, on the Esplanade Road, New Orleans, La. The letters U S ⊙ P B M are cut near the bolt. Elevation 9m.1593.

U. S. P. B. M. 3 is center of copper bolt leaded horizontally in the east face of mid-

dle brick gat... of Gentilly gate on east side of Fair Grounds, New Orleans, La. The bolt is lead... in the middle brick of the fifth (5th) course above the surface of th ground. The le...rs U⊙S are cut near the bolt. Elevation, $7^{m}.6746$.

U. S. P. B. M. 4 is the center of a copper bolt leaded horizontally in wall of Fo Macomb, Chef Menteur, La., on right-hand side (as you go in) of entrance. There i a moat around the wall. The letters

U S
18⊙82
P B M

are cut about the bolt. Elevation, $8^{m}.5427$

U. S. P. B. M. 5 is a copper bolt leaded vertically near center of old draw-bridg pier, just north of iron truss bridge over the Rigolets, near Rigolets Station, on th N. O. and M. R. R., La. Elevation, $6^{m}.9509$.

U. S. P. B. M. 6 is a copper bolt leaded in top of marking-stone set to within 0.2 ft. of its top, in high point of ground just east of East Pearl River, in Miss. It is 20 meters east of the eastern pier of iron truss bridge over the East Pearl River, on th N. O. and M. R. R., and 27.2 meters south of the center of main railroad track, b fence in front of land of Mrs. Sarah Selph. Elevation, $9^{m}.5649$.

U. S. P. B. M. 7 is center of cross-cut in top of marking-stone, marked U. S., set i ground just north of north fence of house lot of Pat. Ferril, near Claiborne Station on N. O. and M. R. R., Miss. It is 18 meters south of center of main track, 12 meter east of east end of statio... ...rs west of west end of wood-shed o N. O. and M. R. R.; the ... d 36 meters, being measured paralle to railroad track. Eleva...

U. S. P. B. M. 8 is top of ... d U. S., set in ground in northwes corner of small yard, in fro... which the section-house at Toulm Station, N. O. and M. R. R., M... Stone is about 10 meters south o center of main track. Elevatio...

U. S. P. B. M. 9 is top of mar... ked U. S., set within the southeas corner of fence surrounding the ... on Winfield, near Waveland Station N. O. and M. R. R., Miss. The ... e intersection of Waveland road an lane, between the lands of Mr. Shaw ... nfield. Stone is about 32 meters from southwest corner of station-house. ... $11^{m}.0606$.

U. S. P. B. M. 10 is center of cop... ded horizontally in face of southern brick wall of vestibule of Catholic ch... Saint Louis (Shieldsboro'), Miss. It is about half way between side ... tibule and main front wall, and about 1 meter above the ground. El...

U. S. P. B. M. 11 is a copper ... top of marking-stone, marked U. S., set in ground, by fence, and ne... ...er of fence of southwest plot of land at intersection of N. O. and M. R. R. ...ck an... Front street, Bay Saint Louis, Miss It is about 12 meters south of center of track, and 514 meters west of west end of bridge over Bay St. Louis. Elevation, $12^{m}.8623$.

U. S. P. B. M. 12 is copper bolt leaded in top of marking-stone, marked U. S., set in ground within northwest corner of fence surrounding plot of ground on which the tool-house of N. O. and M R. R. section-house No. 9 is situated, at Henderson's Point, Miss. Stone is about 32 meters west of west side of house, and 8 meters south of center of track. Elevation, $9^{m}.3391$.

U. S. P. B. M. 13 is copper bolt leaded in top of marking-stone, marked U. S., set in ground between pump-house and water-tank at Pass Christian Station, N. O. and M. R. R., Miss. It is a little inside of north line of pump-house and tank, and about 3 meters from west side of pump-house. Pump-house is about 9 meters south of track. Elevation, $9^{m}.7359$.

U. S. P. B. M. 14 is top of copper bolt leaded in top of marking-stone set in ground directly opposite the New Orleans 62-mile post and 8 meters north of center of track of N. O. and M. R. R. Elevation, $15^{m}.7654$.

U. S. P. B. M. 15 is top of marking-stone set in ground 24 meters north of center of track, about 873 meters east of New Orleans 65-mile post, and about 639 meters west of New Orleans 66-mile post, on the N. O. and M. R. R. Three pine trees, each marked with five narrow blazes, are near the stone. Elevation, $14^{m}.0708$.

U. S. P. B. M. 16 is center of copper bolt, leaded horizontally in center of fifth (5th) brick of the fifteenth (15th) course above water-table, in the west wall of jail at Mississippi City, Miss. The bricks are counted from northwest corner of building. It is marked

U S
⊙
B M

Elevation, $12^{m}.7428$.

U. S. P. B. M. 17 is copper bolt leaded in top of marking-stone set in ground near west end of depot platform, and 11 meters south of center of track at Beauvoir Station, N. O. & M. R. R., Miss. Elevation, $14^{m}.2322$.

U. S. P. B. M. 18 is center of copper bolt leaded horizontally in center of second (2nd) brick of the fourteenth (14th) course above sidewalk, in east wall, near southeast corner of brick building on southwest corner of Back Bay road (or Mule street) and Jackson street, Biloxi, Miss. Elevation, $13^{m}.1006$.

... B. M. 1 is copper bolt in top of stone in ground in woods on Calhoun
t mouth of Illinois River. It is 60 meters from edge of woods on Illinois
nd 150 meters from edge of woods on Mississippi River. Elevation, 134m.5101.

P. B. M. 2 is top of copper bolt in top of stone in ground in woods at mouth of
River on left bank, 157 meters back from river, 4 meters east of fence, 15
outh of road, 2,100 meters above Catholic Church in Grafton, Ill., and within
formed by three pecan trees. Elevation, 136m.3645.

P. B. M. 3 is copper bolt in top surface of doorstep of Catholic Church,
, Ill. It is 22 centimeters from front of step, and 13 centimeters from north
Elevation, 139m.3116.

P. B. M. 4 is copper bolt in east end of doorstep of eastern door in Allen's
uilding, adjoining Grafton Flouring Mills, Grafton, Ill. It is 104 millimeters
nt surface of step. Elevation, 142m.0719.

P. B. M. 5 is copper bolt leaded in the natural rock on side of bluff above
ater mark. It is 450 meters below flour mill at Jersey Landing, Ill., and about
below Grafton, Ill. The letters U. S. P. B. M. are cut in the rock near the cop-
. Elevation, 141m.4305.

P. B. M. 6 is copper bolt leaded vertically in the natural flat rock; top of rock
th surface of ground. It is 5,600 meters below flour mill at Jersey Landing,
lies near high-water mark and about 9 meters west of the mouth of small
which comes out of valley facing the "Eagle's Nest." Elevation, 135m.0339.

P. B. M. 7 is copper bolt in natural rock on hillside, in woods 19 meters above
ater mark, and 3,150 meters below mouth of Piasa Creek. The letters U. S. P.
e cut near bolt. Elevation, 143m.7181.

P. B. M. 8 is copper bolt leaded vertically in east end of water-table, on the
ide of the Alton water works building in sixth window from corner, Alton,
e letters U. S. cut near the bolt. Elevation, 136m.9468.

P. B. M. 9 is copper bolt leaded vertically in south end of doorstep, in north
rner of German Catholic Church in Alton, Ill. Elevation, 154m.4612.

P. B. M. 10 is top of copper bolt in stone post in ground in woods on land of
Gringering, about three hundred meters east of his house, and 5 miles below
Ill. It is about 500 meters from river bank. Elevation, 136m.0457.

P. B. M. 11 is top of copper bolt in stone in ground in woods 450 meters back
angulation station Gillen, 2 meters north of honey-locust tree, about 10 meters
f road, and about 11 miles below Alton, Ill. There is a road leading back
ver past this bench-mark. Elevation, 132m.2312.

P. B. M. 12 is top of copper bolt in stone in ground in corner of grove 20 meters
Columbia road, 12.8 miles above steel railroad bridge at St. Louis, Mo. It is
of —. —. Chambers, about opposite lower end of Wilson's Island No. 5. Ele-
145m.6611.

P. B. M. 13 is top of copper bolt in top of stone in ground in small grove on east
Baden and Saint Louis street-car track, 6.4 miles above the railroad bridge at
ouis, Mo. It is 110 meters south of northern terminus Baden street-car track,

is 29.5 centimeter from front face and 10 centimeters west of buttress adjoining doo step. Elevation, 59m.3461.

U. S. P. B. M. 17 is top of copper bolt leaded vertically in north end of north doo step of E. Mueller's store, north of northeast corner of Main and Franklin street Carondelet, Mo. Elevation, 138m.6820.

U. S. P. B. M. 18 is center of copper bolt leaded horizontally in water-table in nort east corner of guard-house, at Jefferson Barracks, Mo. Elevation, 156m.8992.

U. S. P. B. M. 19 is center of copper bolt leaded horizontally in east face of sto in fourth course from top in east end of culvert at Cliff Cave, Mo., on Iron Mounta Railroad. Elevation, 126m.1949.

U. S. P. B. M. 20 is top of copper bolt leaded vertically in upper surface of thi stone from top, in south-west retaining wall of arched culvert, over White Hou Creek, on Iron Mountain Railroad. Elevation, 131m.0967.

U. S. P. B. M. 21 is top of copper bolt leaded vertically in top stone directly ov keystone of arch on north side of arched culvert, 650 meters below Jefferson Statio Mo., on Iron Mountain Railroad. The letters U. S. P. B. M. are cut near the bol Elevation, 130m.0469.

U. S. P. B. M. 22 is top of copper bolt leaded vertically in southern abutment southern approach to railroad bridge on Iron Mountain Railroad at Kimmswic Mo. Elevation, 130m.69

U. S. P. B. M. 23 is cent d horizontally in east face of stone northeast corner of sout bridge, 400 meters below station-hou at Sulphur Springs, Mo. E

U. S. P. B. M. 24 is center of aded horizontally in natural rock overhanging bluff 1,000 meters house at Illinois Station, Mo. This the first bluff that is seen from , standing opposite point where Ir Mountain Railroad leaves Mississip Elevation, 131m.7525.

U. S. P. B. M. 25 is top of copper vertically in Cornice Rock, about meters from river edge of rock, and neters south of foot of Cornice Islan and 1,000 meters south of mouth of Plati Creek, Jefferson Co., Mo. Elevatio 123m.6392.

U. S. P. B. M. 26 is top of copper bol vertically in top of Robber's Rock, north side, and 1,736 meters above Rusl Mo. Robber's Rock is large sandsto on beach, and is plainly visible for thr s of a mile up or down the river. El vation, 124m.6578.

U. S. P. B. M. 27 is center of copper bolt leaded horizontally in limestone wall (natur rock), at Rush Tower, Mo., and 11 meters from post-office building. Elevatio 126m.6790.

U. S. P. B. M. 28 is top of copper bolt leaded vertically in large limestone bowld on beach, 1,000 meters above Brickey's Mill, Cliff P. O., Ste. Genevieve Co., Mo. Th beach is a little lower than extreme high-water mark. Elevation, 121m.5487.

U. S. P. B. M. 29 is center of copper bolt leaded horizontally in limestone wa (natural rock) at end of bluff about 4 meters north of a red oak tree, about 30 mete north of——— Maple's farm-house and three miles below Cliff P. O., Ste. Genevieve Co Mo. This bench-mark in about one foot above surface of ground at base of bluff an is about 8 meters above high water-mark. Elevation, 131m.0374.

U. S. P. B. M. 30 is center of copper bolt leaded horizontally in natural rock 1,5 meters above White Sand Depot Landing, Ste. Genevieve Co., Mo. It is about 2 meters north of southern end of bluff. The letters U. S. P. B. M. are cut near the bol Elevation, 124m.6871.

U. S. P. B. M. 31 is center of copper bolt leaded horizontally in natural rock wa 14 meters north of a spring at Limestone Point, Ste. Genevieve Co., Mo., and is abo 2¼ miles above Ste. Genevieve, Mo. The letters U. S. P. B. M. are cut around the bol Elevation, 128m.9043.

U. S. P. B. M. 32 is top of copper bolt leaded vertically in west end of doorstep south side of Rozier's warehouse, southwest corner Main and Washington streets, St Genevieve, Mo. Elevation, 125m.1543.

U. S. P. B. M. 33 is center of copper bolt leaded horizontally in south side at soutl east corner of public school building in Ste. Genevieve, Mo., four inches from corn in fifth course of stones below the bricks. The letters U. S. P. B. M. are cut ne the bolt. Elevation, 128m.3151.

U. S. P. B. M. 34 is center of copper bolt leaded horizontally in east face of large co ner-stone of engine-house of Quarrytown Grindstone Works, at Quarrytown, Mo three miles below Ste. Genevieve, Mo. The letters U. S. P. B. M. are cut near tl bolt. Elevation, 123m.2542.

U. S. P. B. M. 35 is center of copper bolt leaded horizontally in west end of wate table in southwest corner of storehouse belonging to E. S. Lanbaugh, on northea corner of Second and Walnut streets, Ste. Mary's, Mo. The bolt is countersunk abo 5 millimeters in the stone. The letters U. S. P. B. M. are cut near the bolt. Elev tion, 124m.6617.

U. S. P. B. M. 36 is center of copper bolt leaded horizontally in southwest corner of Martin Roundstone's ice-house on east side of Walnut street, Ste. Mary's, Mo. The letters U. S. P. B. M. are cut near the bolt. The bolt is in fifth course of stones from bottom. Elevation, 126m.7787.

U. S. P. B. M. 37 is top of copper bolt leaded vertically in stone post set in ground in woods about 4 miles below Ste. Mary's, Ste. Genevieve Co., Mo. It is 990 meters back from river and 24 meters west of lane running south from river road. Lane turns off from river road in vicinity of John Lawrence's house. This bench-mark is S. 40° W. from farm-house, 7 meters N. 75° W. from ash tree, and 4½ meters N. 52° E. from box-elder tree. Elevation, 118m.1124.

U. S. P. B. M. 38 is horizontal copper bolt in water-table of drug store northeast corner of Schuchert's Block, Chester, Ill. Elevation, 122m.0907.

U. S. P. B. M. 39 is horizontal copper bolt in front face of Cole Brothers' stone elevator, 1.32 meters east of the southwest corner and the same distance above the ground, 1,240 meters below Chester, Ill. Elevation, 122m.2673.

U. S. P. B. M. 40 is top of copper bolt in stone monument set in southeast corner of woods 576 meters back from a long lane just west of large wheatfield from turn of road, 40 meters north of farm-house of Marcus Peto. It is 2 meters south of elm tree 4 feet in diameter, 12 meters west from hackberry tree 18 inches in diameter, and 200 meters northwest of house not occupied. Elevation, 118m.0519.

U. S. P. B. M. 41 is top of copper bolt in stone in ground 50 meters south of end of lane, 1 meter from fence, 1,420 meters back from river at Bois Brulé P. O., Perry Co., Mo. Elevation, 116m.5760.

U. S. P. B. M. 42 is center of copper bolt set horizontally in vertical face of natural rock at upper extremity of bluff 643 metres below Grand Eddy post-office, Perry Co., Mo. It is about 3½ meters below upper end of U. S. water-gauge, and 14 meters below extreme upper point of the bluff rocks. The letters U. S. P. B. M. are cut in the rock near the bolt. Elevation, 119m.4255.

U. S. P. B. M. 43 is center of copper bolt leaded horizontally in a large rock in the woods about 4 miles below Grand Eddy, Perry Co., Mo. It is 740 meters below a house, 175 meters back from the river, and 30 meters back from edge of timber, and at the upper end of a stretch of prairie land which extends down to 76 landing. Elevation, 118m.7714.

U. S. P. B. M. 44 is top of copper bolt leaded vertically in a large bowlder, 10 feet by 10 feet by 6 feet, 6 meters from edge of bank, 17 meters above second gate above farm-house of Napoleon Gill, 100 meters above barn on Cape Cinque Hommes, Perry Co., Mo., and 3½ miles above Wittenberg, Mo. Elevation, 118m.5512.

U. S. P. B. M. 45 is center of copper bolt leaded horizontally in stone foundation-wall of Wittenberg Flouring-Mill, at Wittenberg, Mo., on side facing the river between the ground-floor door and down-river corner of mill. Elevation, 116m.5964.

U. S. P. B. M. 46 is center of copper bolt leaded horizontally in east face of rock, 2 meters east of road, 400 meters below Wittenberg, Mo. It is situated between the houses of Denny and Tucker, 23 meters from the former and 31 meters above the latter's house. It is 11 meters below Denny's shop and 29 meters above Tucker's barn. Elevation, 116m.4716.

U. S. P. B. M. 47 is top of copper bolt leaded vertically in the point of rocks 95 meters below "Tower Rock," Perry Co., Mo., and opposite the upper end of Grand Tower, Ill. It is 15 meters east of an iron bolt leaded vertically in the rock and marked "U. S. 53." The letters U. S. P. B. M. are cut near the copper bolt. Elevation, 111m.0031.

U. S. P. B. M. 48 is center of copper bolt leaded horizontally in face of rock at Birmingham Point, Perry Co., Mo. It is 813 meters above the mouth of Applé Creek, and 28½ meters above a scrubby, gnarled sycamore tree growing in the rocks. The rocks here are conglomerate in horizontal strata, and from the river present the appearance of a stairway. The letters U. S. P. B. M. are cut near the bolt in the rock. It is about 30 meters above a living spring, which comes up out of the gravel just below the strata of rock. Elevation, 110m.0317.

U. S. P. B. M. 49 is top of copper bolt leaded vertically in the bluff rock 3,655 meters below mouth of Apple Creek, Cape Girardeau Co., Mo. In front of this bench-mark are three very large rocks standing out from the bluff and partly detached therefrom. Elevation, 110m.2011.

U. S. P. B. M. 50 is center of copper bolt leaded horizontally in natural rock in river bluff 712 meters below rock called "The Devil's Tea Table," in Cape Girardeau Co., Mo. Elevation, 110m.2257.

U. S. P. B. M. 51 is center of copper bolt leaded in the steeply-inclined face of the last reliable ledge of rocks of the chain extending south from Moccasin Springs, Mo., and at the point where the bluffs begin to recede from the river 2,500 meters above Bainbridge Creek. The letters U. S. are cut in the rock. Elevation, 109m.1341.

U. S. P. B. M. 52 is a horizontal copper bolt set in vertical face of ledge of rocks 35 centimeters thick. The bolt is 1.2 meters above the ground, is 775 meters below Henry

Shineman's house and 565 meters above the foot of the bluffs. These bluffs are 4 mi above north end of Cape Rock, Cape Girardeau Co., Mo., ¾ mile from river, and land of Elisha Sheppard's heirs. Elevation, 110m.5744.

U. S. P. B. M. 53 is center of horizontal copper bolt, set in vertical face of ledg just below a ravine at the lower end of Cape Rock. Its elevation is about hig water. Elevation, 108m.7640.

U. S. P. B. M. 54 is a horizontal copper bolt in the outer vertical face of sto step, which extends under buttress at the northeast corner, second entrance from th north, to Marble City Hotel, on Water street, Cape Girardeau, Mo. Elevatio 111m.7495.

U. S. P. B. M. 55 is horizontal copper bolt in vertical face of good homogeneo hard rock, just below and near the southeast corner of St. Vincent's College, abo 45 meters west of river, in south part of Cape Girardeau, Mo. Elevation, 114m.773

U. S. P. B. M. 56 is horizontal brass key, in vertical face of solid rock of fair hard homogeneous sandstone, or granite, very white when cut. Ledge forms bank river, and is at lower end of Cape Girardeau, in front of St. Vincent College. It about 35 meters east of railroad track. Elevation, 107m.1247.

U. S. P. B. M. 57 is center of horizontal copper bolt, set in smooth vertical fac in ledge of blue, or gray, limestone, at its upper, or western, extremity, on the land the Taylor estate. It is ... ground, 1 meter below top of vertic part, and 10 meters belo... disappears under the ground. It S. 70° E., 75 meters from ... Creek, and 1,574 meters above low U. S. water-gauge at Gray's ... just in view of the lower part of Ca Girardeau, Mo. The letters ... cut in the face of the rock. Elev tion, 110m.9056.

U. S. P. B. M. 58 is center mar... tal copper bolt leaded in the vertic face, looking toward the river, o... e of three large rocks, the lowest an largest of which forms the bank ... and is known as "Counterfeit Rock, or "Standing Rock of the Grand ... is 10 meters from the top of the riv bank, 80 meters above the line betwee... hew Roe and H. S. Wray, 600 mete above Wray's Landing on the land of ... tthew Roe, situated about three mil above Commerce, Mo. It is about 0.... bove the ground. The letters U. S. I B. M. are cut in the rock. Elevation, ...

U. S. P. B. M. 59 is the center of a ... tal copper bolt leaded in the steepl inclined face, looking toward the river, ... rge silicious rock mostly covered wit earth, being one of a group of many in a ra... e 1,190 meters above U. S. P. B. M. 6 in Commerce. It is 0.6 meters above the gr... nd, and about 60 meters back from th river, the ground rising in this distance 15 meters. It is in a shallow, rocky ravin at upper side of the first strip of cultivated land, near the river, south of the bluff on land of Mrs. C. Halfner. The letters U. S. P. B. M. are cut in the rock. Elev tion, 118m.7540.

U. S. P. B. M. 60 is point in center of horizontal copper bolt leaded in vertical face ledge, looking toward the river 0.55 metres above the ground and 3.37 metres abov the high water of 1858. The top surface of this rock or ledge, which extends acro the street, forms the road bed. It is just in front of a point about 30 meters abov Wm. Anderson's large brick house on elevated site at the north or upper end of Com merce, Mo. There are a large number of large pieces of rock lying on the bank he that have from time to time rolled down from the same general ledge, but the on selected is so large and extends back in the bank so far that it is reliable. Elev tion, 110m.5032.

U. S. P. B. M. 61 is center of horizontal copper bolt set in front or east face of found tion of Wm. Anderson's large brick dwelling-house at the upper end of Commerce, M It is 2 meters north of center of front entrance and 36 centimeters above the groun Elevation, 116m.6307.

U. S. P. B. M. 62 is mark in center of horizontal copper bolt set in the vertical fa of the northwest abutment of stone culvert under road over Muddy Creek, 1 met above the ground, 75 meters from the top of the river bank and 1,960 meters abov Santa Fé Store, which latter is opposite Commerce, Mo., in the State of Illinois. Th foundation or masonry rests on the natural rock. The letters U. S. P. B. M. are cu in the rock near the bolt. Elevation, 104m.6078.

U. S. P. B. M. 63 is 185 meters right up the same creek (Muddy Creek) in the le hand ravine going up from the culvert in which is U. S. P. B. M. 62. It is center o copper bolt set in vertical face of a very large rock on part of the ledge just on th right of the creek going up, 1.5 meters above the ground, 1.5 meters below the to of the rock, and 2 meters from the projecting end. Elevation, 108m.7967.

U. S. P. B. M. 64 is top of copper bolt in top of stone in ground 1,260 meters bac from river, 1 meter north of fence on north side of road leading east from Goose Islan P. O., or Atherton's Landing, about 19 miles above Cairo, Ill. Elevation, 107m.5416

U. S. P. B M. 65 is top of copper bolt in top of stone in ground in woods abou 1,500 meters back from river, and 8½ miles above Cairo Post-Office, Alexander Co.

. It is 26 meters from graded road (otherwise known as levee), and 93 meters school-house for negroes, and 2¼ miles below Spies' Mills. Elevation, 103^{m}.4605.

. P. B. M. 66 is top of copper bolt in stone post in open woods. It is 61 meters a point on the I. C. R. R., which point on the railroad is 391 meters north of hree-mile post" from Cairo, Ill. Elevation, 101^{m}.4777.

PTION OF PERMANENT BENCH-MARKS BETWEEN KEOKUK, IOWA, AND GRAFTON, ILL.

P. B. M. 1 is top of copper bolt leaded vertically into coping of shore side of ock of Des Moines Rapids Canal, Keokuk, Iowa. Bench is in recess between teps and stone pier of lower hydraulic tower, on south side of pier. Elevation, 370.

P. B. M. 2 is copper bolt leaded horizontally in south face of Iowa shore pier . bridge, Keokuk, Iowa, 8 inches above bench of pier, in the tenth stone from ıd. Elevation, 156^{m}.7516.

P. B. M. 3 is copper bolt leaded horizontally in southwest corner of three-story uilding, owned by Mr. Patterson, facing on Water street, second door from cor- Johnson street, Keokuk, Ia., 8 inches above west door-sill, on inner side of outer 0 feet from corner of Water and Johnson streets. Elevation, 161^{m}.3896.

P. B. M. 4 is small conical hole in rock at intersection of cross-cut in upper of top stone of buttress of Des Moines River bridge. Elevation, 158^{m}.4243.

P. B. M. 5 is copper bolt leaded horizontally into north wall of brick building, from northeast corner, and three feet from ground. Building is in upper end andria, Mo., facing river, and 60 feet from bank. The north wall faces slough ng into river, and 50 meters from it. Building owned by Chas. Bocker; post- cated in building. Elevation, 158^{m}.0087.

P. B. M. 6 is copper bolt leaded horizontally in upper corner of stone masonry st side of northeast corner of Baptist Church at Gregory's Landing, Mo. is 150 meters north from junction of railroad and wagon road. Elevation, 390.

P. B. M. 7 is copper bolt leaded vertically in marking-stone set at root of oak l meters west of railroad. Stone is 1.7 meters west of tree in northeast corner l, 10 meters south of small ravine, 650 meters below bridge No. 14. Tree is 12 in diameter. Elevation, 157^{m}.2349.

P. B. M. 8 is copper bolt leaded horizontally in north wall of Down's Hotel. , Mo. Bolt is in fifth stone from ground, fourth stone from corner of wall made e door entrance, and in second stone from first window west of office entrance. s on southwest corner of Lewis and Fifth streets. Elevation, 156^{m}.7856.

P. B. M. 9 is copper bolt leaded horizontally in east side of back foundation of n Methodist Episcopal Church, corner of Sixth and Washington streets, Can-). Bolt is in third stone from ground and in second from north corner, and r under window facing east. Elevation, 156^{m}.5849.

P. B. M. 10 is copper bolt leaded vertically in top surface of southeast corner of butment of railroad bridge No. 35 over Wyaconda Creek. Bolt is 2 feet from ace, 4 feet from east face of abutment, and about 1 mile above La Grange, Mo. on, 153^{m}.6120.

P. B. M. 11 is copper bolt leaded horizontally in northeast corner stone of berry & Schneider's tobacco works, situated on southwest corner of Wash- street and K and St. L. R. R. at Lagrange, Mo. Bolt is in east face, 15 inches orner of stone and 2 feet from ground. Elevation, 153^{m}.5792.

P. B. M. 12 is center of copper bolt leaded horizontally in third course of masonry ottom and ninth from top of west abutment of Quincy R. R. bridge, West , Mo. Bolt is in north face 2 inches from east corner. Elevation, 151^{m}.7187.

P. B. M. 13 is copper bolt leaded vertically in top surface of top stone of north- rner of north pier forming south face of north abutment of covered railroad over the Fabius River. Bolt is near the center of stone 5 feet below and 8 feet rail. Elevation, 151^{m}.9146.

P. B. M. 14 is top of copper bolt leaded vertically in top surface of stone, form- st end of north pier to railroad bridge over North River. Bolt is 8 inches from dge of stone, 2 feet from west edge, and 14 inches from base of strut. Eleva- 50^{m}.8065.

P. B. M. 15 is copper bolt leaded vertically in stone post set in northeast corner of ited field, 5 meters from wagon road, 15 meters west of railroad, 20 meters from one of two elm trees standing alone in wagon road, fence forming line between and cultivated ground, 466 meters north of Hilton Station. Elevation, 149^{m}.7508.

P. B. M. 16 is copper bolt leaded horizontally in face of natural rock at east ce of tunnel at Missouri end of railroad bridge at Hannibal, Mo. Bolt is in

nd on south side of tunnel, 7 feet south of entrance and about 4 fe Elevation, 155m.2651.
' is copper bolt leaded vertically in top surface of east stone of nor a all railroad bridge 1 mile below Hannibal, Mo., and 50 mete n e of Mr. Johnson. Elevation, 147m.8009.

18 is copper bolt leaded vertically in top of top course of masonry river side rth end of principal abutment of railroad bridge across Lick Cree 800 meters r depot at Saverton, Mo. Elevation, 147m.3801.

U. S. P. B. M. 19 is marking-stone planted in corner of yard of Catharine Hayes miles south of Saverton, 1¼ miles above Ashburn. Stone is 8 meters southwest southwest corner of house, and 25 meters from river bank, a little below dam at G bert's Island. Elevation, 151m.7497.

U. S. P. B. M. 20 is copper bolt set vertically in top of marking-stone set on li of rail fence 8 meters east of large maple tree on east bank of small creek bed, 3 mete north of bridge over creek. Stone is 7 meters south of wagon road, 17 meters we of railroad, 23 meters south of south corner of house of Mr. Warner, and ½ mile nor of Ashburn, Mo. Elevation, 150m.5762.

U. S. P. B. M. 21 is marking-stone planted in east edge of cultivated field about meters from south bank of Salt River, at place where Keokuk and Saint Louis Railro crosses the river. Sto rs to the west of track, nearly opposi the south end of the t idge. Elevation, 145m.2055.

U. S. P. B. M. 22 is tically in marking-stone in southwe fence corner of fence and one south. South fence stops corner, and begins agai t, on east and west fence. Stone is meters west of railroad uth of Salt River. Elevation, 148m.98

U. S. P. B. M. 23 is c izontally in first layer of stone bel brick in northeast face northwest corner of Water and Ma streets, Louisiana, Mo. north of door in same wall of buildin Elevation, 148m.9719.

U. S. P. B. M. 24 is copper bolt y in top surface of top stone formi the northeast corner of the w railroad bridge over Mississippi Riv at Louisiana, Mo. Top of b the surface of the stone. Elevatio 148m.6907.

U. S. P. B. M. 25 is center bolt in side of natural rock 7 mete south of railroad, 9 meters 14 inches in diameter, on bank abov 500 meters below railroad br and 6,000 meters below railroad brid across Mississippi River at Five notches cut in tree. Elevatio 147m.2828.

U. S. P. B. M. 26 is copper bolt leaded vertically in top of marking-stone set intersection of two fences on south side of lane and west of railroad. Lane is 5 mete wide. The north fence stops before it reaches as far east as the south fence. A sm creek is 3 meters north of the north fence. A row of apple trees is just inside t north fence. Stone is 5¼ meters west of railroad and 15 meters west of river; abo 60 meters east of old log-house of Peter Yaeger, and about 3 miles above Clarksvil Mo. Elevation, 146m.6472.

U. S. P. B. M. 27 is center of horizontal copper bolt leaded in the natural rock side of small bluff bank 3¼ meters east of railroad track, below wagon road, 12 mete from river bank, 440 meters above vinegar works at Clarksville, Mo., and 120 mete below mouth of Calumet Creek. It is between railroad and house of Philip Beda Elevation, 148m.0183.

U. S. P. B. M. 28 is copper bolt leaded horizontally in the southeast corner sto of Carroll House, Clarksville, Mo. Stone is at the head of stairs leading to baseme Bolt is set in south face of stone about 10 inches above the sidewalk. Elevatio 146m.5610.

U. S. P. B. M. 29 is top of copper bolt leaded vertically in top surface of markin stone set in the ground 5 meters east of the Suy Levee, opposite Clarksville, M about 50 meters east of ferry landing in Calhoun County, Illinois. Stone is 220 mete along the levee below where levee crosses chute. Elevation, 142m.8844.

U. S. P. B. M. 30 is copper bolt leaded vertically in top surface of marking-stone in the ground on east side of Suy Levee at intersection of plantation road, on south road, which crosses levee and continues to the river. Levee is 50 meters east of riv A large elm stump 6 feet in diameter and 10 feet tall stands in the road 20 met west of levee. Stone is opposite Island No. 463, about one-third its length above t lower end, and about 3¼ miles below U. S. P. B. M. 29, opposite Clarksville. Elevatio 142m.8681.

U. S. P. B. M. 31 is copper bolt leaded vertically in top of marking-stone set on e side of levee at its base, 4 meters east of the middle of levee, in fence corner closing field with woods on north side and levee on west side. It is about 100 mete east of river and 175 meters northwest of house occupied by Mr. Gain and owned Messrs. Rock and Baker. Elevation, 142m.0102.

U. S. P. B. M. 32 is conical hole in top surface of rock projecting from side of wagon road, about half way up steep hill on north bank of small stream, 10 meters north of middle of stone culvert. Rock is at root of two poplar trees growing about 1 foot apart. Bench is at intersection of cross, 6 inches from west edge and 10 inches from south edge of rock, and about 50 meters east of east shore of Hamburg Bay. Elevation, 148m.6000.

U. S. P. B. M. 33 is top of copper bolt leaded vertically in top surface of natural rock projecting from east side of wagon road about 240 meters south of house of Mr. Blacksmith, and about 4 miles north of Hamburg, Ill. The bolt is 18 inches from corner, and 10 inches from the two sides of the stone, only one corner of which projects. Elevation, 163m.0372.

U. S. P. B. M. 34 is copper bolt leaded horizontally in the north face of natural rock forming south side of the first creek south of Hamburg, Calhoun County, Illinois. Bench is about 120 meters east on road from where the road makes a sharp bend from south to east. There are a mill and two houses at the turn of the road. Bench is about 5 meters north of fence around orchard. Bolt is about 1 foot below the top surface of rock, and about 4½ feet above creek bottom, which is of stone. Rock is in layers, the bolt being in top layer. Elevation, 141m.6910.

U. S. P. B. M. 35 is point 1½ inches from south corner and ½ inch from east side of shore line triangulation stone set by Assistant Engineer John Eisenmann. Stone is 38 meters east of river bank, about 250 meters below Island No. 482, and 3½ meters north west of large elm tree marked with two triangles opposite midway between two houses on Westport Island. Elevation, 139m.9151.

U. S. P. B. M. 36 is top of copper bolt leaded in the top of marking-stone set about 8 meters from the river bank, on the Illinois shore, a short distance south of a point opposite the head of Islands Nos. 487, 486, and 485, and about 1,190 meters above warehouses at Red's Landing, Calhoun County, Illinois. It is ½ meter south of lower fence of two on land of one Ira Lawson, about opposite the head of the aforesaid islands, and about 50 meters north of the boundary line between the land of the above-named Ira Lawson and the land of one John M. Lewis. Elevation, 139m.6604.

U. S. P. B. M. 37 is cross about in the middle of triangulation stone set by Assistant Engineer John Eisenmann at the root of a large poplar tree about 10 meters from small house and 5 meters from fence surrounding house. The house is opposite the foot of Sterling Island. Elevation, 139m.5688.

U. S. P. B. M. 38 is top of marking-stone set by Assistant Engineer John Eisenmann 1½ meters west of foot of sycamore tree blazed and marked with a triangle. Stone is 50 meters east of river bank and 27 meters east of road running to Hogville. It is about 800 meters south from Church's Landing, and about 400 meters north from warehouses at Hogville Landing, Calhoun County, Illinois. Elevation, 138m.7069.

U. S. P. B. M. 39 is top of copper bolt leaded vertically in top of marking-stone set in the ground ½ meter inside the fence on the west side of the field of J. H. Eildemann, about 100 meters north from upper landing warehouse at Turner's Landing, Calhoun County, Illinois. Elevation 139m.5747.

U. S. P. B. M. 40 is top of triangulation shore line marking-stone set by Assistant Engineer John Eisenmann about 90 meters back from Illinois bank of Mississippi River, about 600 meters south of foot of Island No. 197, and about 2,900 meters south from the lower Turner's Landing warehouse. Elevation, 138m.6351.

U. S. P. B. M. 41 is center of copper bolt leaded horizontally in solid sand rock above and back of the road, 74 meters east and below top of a hill at point of bluff at West Point, Calhoun County, Illinois, facing the north. It is about 1 meter above level of road, and is about 150 meters around the point from the warehouse at West Point. Elevation, 141m.9651.

U. S. P. B. M. 42 is center of copper bolt leaded horizontally in the north face of large bowlder rock, imbedded partly in the ground about 40 meters around east from northwest corner of the bluff rocks below Hastings' Landing, Calhoun Co., Ill., about 225 meters below warehouse on the land of E. B. Brown. It is third large bowlder at foot of hill on the north side of corner west from the top of bank of small branch that empties in the river below the warehouse, and is about 8 meters east from fence that leads about southwest from the east side of warehouse at landing. Elevation. 141m.0863.

U. S. P. B. M. 43 is center of copper bolt leaded horizontally in the west face of bluff rock about 2½ meters underneath where the upper surface of rocks commence to be exposed at the foot of the hill, about 20 meters around north on west side of hill from southwest projecting corner of the bluffs on the north side of the valley, second one north of Martin's Landing, Calhoun Co., Ill., and first one south of valley where John Zarley lives. Elevation, 138m.9003.

U. S. P. B. M. 44 is center of horizontal copper bolt set in solid bluff rock facing northwest about 900 meters south of Martin's Landing, and about 1,300 meters north of Miller's Landing, Calhoun Co., Ill. It is about 500 meters below a dwelling-house. The bolt is in the upper stratum of exposed rock. Elevation, 138m.7755.

... leaded in solid bluff rock at ... is between the east end of the coke ... the trestle-work of the coal mine.

... west end of solid ... from water's edge at high ... dwelling-house, and one mile below ...

... solid bluff rock about ... of Point Landing, 25 ... Joseph Navar, about 5 meters be- ... of Joseph Navar's dwelling- ...

... IOWA, AND FULTON, ...

... coping of west wall of ... Iowa. Eleva- ...

... coping of west wall ... Marked U. S. P. B. M. Ele- ...

... copper bolt leaded hori- ... south corner of Main ... Marked U. S. P. ...

... west end of south ... south of Viele Station, ...

... northeast corner stone of ... one-half mile south of ...

... stone abutment of ... north of Viele Station, Iowa.

... leaded vertically ... It is near the ... Elevation, 16m.9910.

... copper bolt set ... on north- ... of chimney. ... 170m.5628. ... Madison, Iowa. ... stone on ... meters west of C., ...

... Skunk River, 9 ... vertically in north ...

... miles south of ... in copper ... from the ground.

... bridge, in natural ... saw-mill, is 4 ... hole in copper ... Marked U. S. P.

... bridge over ... vertically in ...

... of copper ... M. 40 is on ...

... Slough, ... Burlington. ... Marked U. S. P.

... about 4½ miles

f the east end of the Burlington bridge, on the line of the C., B. & Q. R. R. › of copper bolt leaded vertically in abutment. Marked U. S. P. B. M. Eleva- m.1635.

P. B. M. 17 is on Robt. Moir's brick store building at Oquawka, Ill. It is center in copper bolt leaded horizontally in stone pillar at southwest corner, about above the water-table. The building stands on the northwest corner of r and Second streets, and is also used for the Journal office. Marked U. S. Mackenzie B. M. 48 is on step of same building. Elevation, 169m.5262.

P. B. M. 18 is on brick building on the southeast corner of Third and Schuyler at Oquawka, Ill. It is center of hole in copper bolt set horizontally on e of northwest corner, 2½ feet above the ground. Marked U. S. P. B. M. Ele- 173m.1367.

P. B. M. 19 is on brick building on the northwest corner of Main and Second Keithsburg, Ill. It is top of copper bolt leaded vertically in stone step on h side of the building, and marked U. S. P. B. M. The building is owned by ons, and used for a furniture store. Elevation, 170m.6252.

P. B. M. 20 is on step of Mr. Rife's brick dwelling on the northwest corner and Fifth streets, Keithsburg, Ill. It is top of copper bolt leaded vertically outhwest corner of upper stone step on south side of house, and is not marked. n, 173m.6488.

P. B. M. 21 is on foundation of water-tank 2 miles east of New Boston, Ill., f C., B. & Q. R. R. It is center of hole in copper bolt set horizontally on e of tank, under a strut, below top of foundation. It is 150 meters east of railroad bridge over Edwards' River. Marked U. S. P. B. M. Elevation, 2.

P. B. M. 22 is on foundation of Keokuk Northern Line Packet Company's se at New Boston, Ill. It is center of hole in copper bolt set horizontally wall near the northeast corner in top of stone foundation, 0.7 meter from Marked U. S. P. B. M. Elevation, 172m.2639.

P. B. M. 23 is on Union Hotel, New Boston, Ill. It is center of hole in copper horizontally in north wall, 0.4 meter from the northeast corner and 1.1 meters ound. Marked U. S. P. B. M. Elevation, 180m.0117.

P. B. M. 24 is on top of southeast corner of stone foundation of tall chimney of mill at Port Louisa, Iowa. Mill now torn down. This is the same bench-mark enzie B. M. 45. Elevation, 172m.3074.

P. B. M. 25 is top of stone set in ground 22 meters south of gate leading to Esq. s house, 7½ miles south of Muscatine, Iowa. Stone is a height of high water of 8 meters north of wagon road, and 15 meters from edge of river bank. A set over the stone, three marking-stakes set 3 feet off, and three small black rees blazed near by. Stone is said to have been set by Major Allen several go. Top of stone is about 1 foot below the surface of the ground. Elevation, 10.

P. B. M. 26 is on brick foundation of Mr. E. Beatty's dwelling on right bank of bout 7 miles below Muscatine, Iowa. It is center of hole in copper bolt set hori- in east side of northeast corner of foundation. Marked U. S. P. B. M. Eleva- m.2544.

P. B. M. 27 is on brick chimney of Hershey's lower saw-mill, Muscatine, Iowa. It r of hole in copper bolt set horizontally on the middle of the east face of chim- ont 3 feet above ground. Marked U. S. P. B. M. Elevation, 173m.8371.

P. B. M. 28 is on water-works chimney, at Muscatine, Iowa. It is center of hole er bolt set horizontally in north face of chimney, about 1.1 meters from the . Marked U. S. P. B. M. Elevation, 174m.2968.

P. B. M. 29 is on north abutment of wagon bridge, 50 meters north of station at ine, Iowa. It is top of copper bolt set vertically in northeast corner of abut- Marked U. S. P. B. M. Elevation, 174m.4349.

P. B. M. 30 is on abutment of C., R. I. & P. R. R. bridge, 3 miles north of Musca- owa. It is top of copper bolt set vertically in top of stone coping of south end t abutment. Marked U. S. P. B. M. Elevation, 174m.7935.

P. B. M. 31 is on abutment of C., R. I. & P. R. R. bridge over Sweetland Creek, 5 miles north of Muscatine, Iowa. It is top of copper bolt leaded vertically in nd of north abutment. Marked U. S. P. B. M. Elevation, 174m.5547.

P. B. M. 32 is in natural rock on line of C., R. I. and P. R. R., about 6 miles above atine, Iowa. It is center of hole in copper bolt set horizontally in face of rock, it has been blasted off for railroad bed. It is 4 feet above the track, 20 feet of center of track, and 740 meters west of bridge 77. Marked U. S. P. B. M. ation, 177m.1381.

P. B. M. 33 is on foundation of pottery owned by John Feasted, at Fairport, It is center of hole in copper bolt set horizontally in west side, near south- corner of stone foundation. This pottery is about 350 meters above railroad on and near the river bank. Marked U. S. P. B. M. Elevation, 175m.3891.

U. S. P. B. M. 34 is on middle pier of bridge over Pine Creek, about 2 miles north of Montpelier, Iowa, on the line of the C., R. I. and P. R. R. It is top of brass bolt leaded vertically in north end of pier. Bridge is No. 60. Marked U. S. P. B. M. Elevation, 175m.0998.

U. S. P. B. M. 35 is on south pier of C., R. I. and P. R. R. bridge No. 52, 1 kilometer south of Montpelier, Iowa. It is top of brass bolt set vertically in west end of pier. Marked U. S. P. B. M. Elevation, 178m.2111.

U. S. P. B. M. 35 *a* is on west abutment of C., R. I. and P. R. R. bridge No. 45, about mile east of the depot at Montpelier, Iowa. It is top of brass bolt leaded vertically in south end of abutment. Marked U. S. P. B. M. Elevation, 175m.9233.

U. S. P. B. M. 36 is on Wm. Karge's brick store and post-office building at Buffalo, Iowa. It is center of hole in brass bolt leaded horizontally in the east side, near southeast corner, 3 feet above the foundation. The building is on the northwest corner of Hecker and Second streets. It is unmarked. Elevation, 178m.4006.

U. S. P. B. M. 37 is on foundation of brick house of Eliza M. Dodge, ½ mile east of Buffalo, Iowa. It is center of hole in brass bolt set horizontally in upper foundation stone on west side, near southwest corner, about 1 meter from ground. House stands about 100 meters north of line of C., R. I. and P. R. R. Marked U. S. P. B. M. Elevation, 179m.4669.

U. S. P. B. M. 38 is on foundation of vinegar works at lower end of West Daven-port, Iowa, near the river bank. It is center of brass bolt set horizontally in wes side, near the southwest corner, about 0.4 meters from ground. Marked U. S. P. B. M Elevation, 179m.0291.

U. S. P. B. M. 39 is on north abutment of Rock Island and Davenport Railroa bridge over the main channel of the Mississippi River. It is top of copper bolt leade vertically in coping of east or upper side of abutment, on a plane with the sidewalk It is 4.1 meters from river face of abutment, and 0.1 meter inside of railing. Marke U. S. P. B. M. Elevation, 180m.8749.

U. S. P. B. M. 40 is on base of stone tower of U. S. arsenal stone building, A, 1865 at lower end of Arsenal Island. It is center of hole in copper bolt leaded horizontall in east side of northeast corner, about 4 feet from the ground. Marked U. S. P. B. M Elevation, 182m.1139.

U. S. P. B. M. 41 is on foundation of the Atlantic Brewery, near C. R. I. and P. R R. depot at Rock Island, Ill. It is center of hole in copper bolt set horizontally i upper foundation stone on the north side at the northeast corner. Marked U. S. P. B M. Elevation, 183m.3053.

U. S. P. B. M. 42 is on south abutment of wagon-bridge crossing from Moline, Ill. to head of Rock Island. It is top of copper bolt set vertically on east end of abutment Marked U. S. P. B. M. Elevation, 179m.5708.

U. S. P. B. M. 43 is on brick basement of H. Smith's dwelling-house at Watertown Ill. It is center of hole in copper bolt leaded horizontally in the west side near th northwest corner. The house stands 50 meters southeast of the C., M. and St. P. R R. depot. It is marked U. S. P. B. M. Elevation, 181m.4283.

U. S. P. B. M. 44 is on brick school-house at Hampton, Iowa. It is center of hol in copper bolt set horizontally 0.5 meters from ground on east side near southeas corner of large new public-school building. It is marked U. S. P. B. M. Elevation 182m.9988.

U. S. P. B. M. 45 is on stone foundation of Baker and Hayward's brick store build ing on levee at Hampton, Ill. It is center of hole in copper bolt leaded horizontall in north side of northwest corner of building, and is at the H. W. mark of 1880 Marked U. S. P. B. M. Elevation, 179m.9437.

U. S. P. B. M. 46 is on stone foundation of H. M. Gilchrist's brick store building a Rapids City, Ill. It is center of hole in copper bolt leaded horizontally in west sid of northwest corner, 4 feet above ground. The building is on the river bank. Marke U. S. P. B. M. Elevation, 181m.8416.

U. S. P. B. M. 47 is on abutment of bridge of C., M. and St. P. R. R. over Barber' Creek, ¾ mile south of Port Byron, Ill. It is top of copper bolt leaded vertically i west end of north abutment. Marked U. S. P. B. M. Elevation, 182m.9513.

U. S. P. B. M. 48 is on foundation of Mr. N. Dorrance's brick store building at Port Byron, Ill. It is center of hole in copper bolt leaded horizontally in west side of south-west corner of stone foundation, and marked U. S. P. B. M. The building stands be-tween Main street and the R. R. track, and about 75 feet from the river bank. Ele-vation, 183m.4013.

U. S. P. B. M. 49 is on iron doorstep of new brick store building of A. H. Wandt a Port Byron, Ill. It is top of north bolt-head of front row of bolts on south doorste on east side of building on east side of Main street. Bolt-head marked with a cros cut through its center by a cold-chisel. Marked U. S. P. B. M. on bricks below. El-evation, 185m.2033.

U. S. P. B. M. 50 is on stone warehouse of Northern Line Packet Co., at Cordova, Ill. It is center of hole in copper bolt set horizontally in south side, near southwest cor-

miles north of Albany, Ill. It is center of hole in copper bolt leaded hori- into the base of cliff 1 foot above ground and about 3.5 meters above a oad, and marked U. S. P. B. M. It is 15 meters east of wagon-road and 90 ast of C., M. and St. P. R. R. Elevation, 188^{m}.6009.

P. B. M. 54 is on abutment of C., M. and St. P. R. R. bridge, 2¼ miles north of Ill. It is top of copper bolt set vertically in west side of south abutment. U. S. P. B. M. Elevation, 182^{m}.2995.

P. B. M. 55 is on south abutment of bridge over Cat Tail Creek of C., M. and . R. It is top of copper bolt set vertically in top of east end of abutment. dge is just south of the line of the C., B. and Q. R. R., and about 2 miles south n, Ill. Elevation, 183^{m}.2978.

P. B. M. 56 is on east end of north abutment of C., M. and St. P. R. R. bridge t Tail Creek, 2 miles south of Fulton, Ill., and about 200 meters south of nd Q. R. R. crossing. It is top of copper bolt set vertically in top of abut- Elevation, 183^{m}.6809.

C 1.

OF ASSISTANT ENGINEER L. L. WHEELER, UPON CUMULATIVE ERRORS IN PRECISE LEVELING.

SAINT LOUIS, *October* 6, 1883.

I have the honor to submit the following report upon the results of investi- of the subject of cumulative errors in leveling.

investigation was commenced some time since, and an incomplete report made he results obtained, with the intention of completing the report when addi- lata, which was being reduced, should be available. In the meantime, con- le additional field-work has been done, under instructions from yourself to t the operations in such a manner as to throw additional light upon the sub- The notes of this work have been reduced, and the results show either that scussion has had a practical value in avoiding operations which introduced tive errors in the work, or that the observers had attained a proficiency not sly shown.

preliminary report has been read by those interested in the subject, some cor- s have been noted, and some sharp criticisms made. I have, therefore, in writ- s report, had the advantage of these facts and the additional data at hand, and ndeavored to show more clearly that the results of leveling operations may cted by such large cumulative errors as to make them unreliable, and that these ative errors may be avoided by proper care in the field-work.

fact that errors appear in the results of leveling which are nearly constant in

... point is the sum of all the errors ...

... a single polygon, we would be ... errors or to some general ... If, however, an observer had ... showed a preponderance ... of some law of the distribu... the same time it must be ... errors, to which all obse... so large as to apparently ... es of observations, however ... while the existence of a gen... It frequently happens ... that the arrangement of th... law of distribution, bu... further extended. In this dis... to base conclusions upon ... portions of the discussion

... errors in the example ... point in the line and plotted ... as abscissas.

... consecutive accidental errors ... curve to one side of the mean ... counterbalanced by acci... the sinusoidal form which ... or less extent in any series ... as has been the case here. ... leveling lines in opposite direc... also true of different observer... the relative errors would b... given on page 425 of "*Nivelle*... leveled the entire perimete... The polygon has 4 sides, and ... The discrepancies betwee... positive, 8 negative, and 2 equal t... at the end is $+247^{mm}$ ... results obtained by the tw... but in this case we hav... with $219^{mm}.2$ too great a... by $28^{mm}.6$. The mean ... by $95^{mm}.3$; or the secon... of both. It is evident, the... is mainly caused by errors of th... may be applied to this poly... receive larger corrections than those of the sec... of the first observer's errors were in operatio... polygon.

... between the north and south lin... Columbus and Memphis, and between Friar...

... are not consecutive, but are sca... is about 101 kilometers. They a... The abscissas are twice the sum ... of the polygons, and the ord... south levelings. The dotte... line is the mean line dete... represent different equation... residuals of the observatio... of observation.

... south lines le... ... give... consecutive. ... leveled ... The lin... were mo... straigh...

... which th...

vergence continued for 110 kilometers.

all attempts to arrive at a value of the precision of levels have been based sumption that the errors increase with the square root of the distance This assumption would be true if accidental errors were the only ones made, number of observations were strictly proportional to the distance leveled. ns of discrepancies between results in instructions for precise leveling have d on the same principle, and are open to the same objection. It has freeen noticed that while the results of each of a number of lines leveled were in limits which were prescribed to be in proportion to the square root of the yet when the sum of several lines was considered, the total discrepancy eed the limit prescribed. In other words, the errors were not proportional are root of the distances and did not follow the law of distribution of accitors. Plus and minus errors were not equally prevalent.

ct is conclusively shown by results given on the plots referred to. Numerples of this unequal distribution of errors may be found in published reports S. Lake Survey, and in the results of levels in Switzerland, Germany, and dia.

mination of the several plots shows that the results there given are affected ative errors, that these errors vary in sign and amount with different observwith the exception of that on Plate III, *that they are nearly if not quite proto the distance leveled.* Theoretically, if the results of levels were affected by t error, the effect of that error would be proportional to the number of ons or instrument stations; but these are so nearly proportiona to the disany one observer, that the distance has been substituted for the number of ons in this discussion. Since the cumulative errors vary with different obhey have been called personal errors.

study of all the reliable levels at hand, we are led to believe that the error a polygon is made up of two parts: First, a constant error which is proporthe perimeter, and may be determined with more or less precision from all ons leveled; and, second, the sum of the accidental errors to which all obs are subject. Having made this assumption, what follows are but logical ns from it, and the proof of the assumption will lie in the results obtained plied to practical examples.

et $2K$=equal the perimeter of a polygon,

$n-s$=the error of closing the polygon,

x=the personal error of the observer,

and v=the sum of the accidental errors in the polygon.

ach polygon would give an equation of the form

$$2Kx-(n-s)=v$$

all the equations we would obtain the normal equation

$$[4K^2]\,x-[2K\,(n-s)]=o.$$

rections, can be determined with four times the precision that the relative personal equation of two observers can be obtained from the same lines leveled once by each observer. In the case of a single observer, the sign of the error is determined, and the error eliminated from the mean of results in both directions, while with two observers we are in ignorance as to the sign and amount of the error made by each, and hence, of the error remaining in the mean, unless we have additional evidence. From this we arrive at the practical conclusion that *each observer should duplicate his own work in opposite directions.*

Having obtained the value of x (or x') from equations (2) or (4) and substituted it in the several equations, the several values of v are obtained.

Let r_0 = probable error of a single observation upon the value of x,
$[vv]$ = sum of the squares of the several values of v,
m = number of observations = number lines leveled.

(5) Then, $$r_0 = \pm 0.6745 \sqrt{\frac{[vv]}{m-1}}$$

Having found r_0 we may compute the probable error of the unknown quantity by the formulæ

(6) $$r_x = \frac{r_0}{\sqrt{p}}, \; p_x \text{ being the weight of } x.$$

The formulæ obtained above relate to either (2) or (4), but what follows relates to (2) alone. Since the several values of v represent the accidental errors of observations, and as these are proportional to the square root of the number of observations, we have, letting n, n_2, n_3, &c., represent the number of observations (instrument stations.)

$$\frac{v_1 v_1}{n_1} = \frac{v_2 v_2}{n_2} = \frac{v_3 v_3}{n_3}, \text{ \&c.}, = \frac{v_m v_m}{n_m}$$

Since, however, in any particular case, the values of n will be very nearly proportional to the distances, we may write

$$\frac{v_1\, v_1}{2\,K_1} = \frac{v_2\, v_2}{2\,K_2} = \frac{v_3\, v_3}{2\,K_3}, \text{ \&c.} = \frac{v_m\, v_m}{2\,K_m}.$$

The expressions $\frac{v_1\, v_1}{2\,K_1}$, $\frac{v_2\, v_2}{2\,K_2}$, &c., represent the squares of the errors of closing of polygons whose perimeters equal unity, which is here taken as one kilometer. To find, then, the probable error of closing a polygon whose perimeter equals one kilometer, or what is the same thing, the probable error of a single leveling per kilometer, we have

(7) $$r = \pm 0.6745 \sqrt{\frac{1}{m}\left[\frac{v\,v}{2K}.\right]}$$

r may be taken as a measure of the precision of an observer's work, but in comparing different observers' work it should be remembered that the relation of n to 2K may be quite different for different observers.

One observer may make his observations under such conditions as to necessitate in the mean 12 instrument stations per kilometer, and the other may only make 6 instrument stations in the same distance.

r being the probable error of a single leveling per kilometer, the probable error of the mean of two levelings would be $\frac{r}{\sqrt{2}}$, and the probable error of the difference of elevation of two bench-marks at the ends of a section consisting of m lines whose aggregate length was [K] would be

(8)* $$R = \frac{r}{\sqrt{2}} \sqrt{[K]} = \pm 0.6745 \sqrt{\frac{[K]}{2m.}\left[\frac{v\,v}{2K}\right]}$$

The above formulæ have been applied to the results of the levels along the Mississippi River, which now extend from Biloxi, Miss., on the Gulf of Mexico, to Fulton, Ill., a distance of 2,100 kilometers. The results will be taken up in sections as they

* The above formulæ for computing the values of r and R are identical in form with those given in "Präcision-Nevellement der Elbe," but were deduced by the writer before he was aware that the same formulæ had previously been obtained. Their use here, however, is restricted to examples where the leveling has been performed *by the same observer in opposite directions* and the personal error eliminated from the results. It is not believed that the formulæ for computing probable errors are applicable to the results of levels, except that the above conditions are fulfilled. The formulæ for personal error and the method of treating the results in order to arrive at an estimate of the precision of the work is believed to be new.

reled, but it will not be necessary to give full explanations in every case. As times happens that more than one result is obtained in one or both directions, form rule has been adopted of combining the mean of the results in one direc- th the mean of the results in the other. The unit of length is one kilometer, unit of vertical measurement is one millimeter. The equations have been so d that the values of x have the signs of corrections; when positive the closing n is too low, and when minus too high.

PRECISE LEVELS FROM AUSTIN TO FRIAR'S POINT, MISS.

section is 43 kilometers in length, and the results of the leveling are published Report of the Chief of Engineers for 1879, page 1944. All lines were leveled site directions an equal number of times by the same observer, and the ons under which the work was done, aside from changes of weather, may be have remained nearly the same throughout. An examination of the table of shows 19 positive and 9 negative discrepancies, and one equal to zero. The the positive discrepancies exceeds the sum of the negative by $+36^{mm}.3$. The the positive discrepancies is $+47^{mm}.6$, and their mean size $+2^{mm}.50$, and the the negative discrepancies $-11^{mm}.3$ and their mean size $-1^{mm}.26$. It is evi- e discrepancies are quite unequally distributed, both with regard to sign and

ing the results of this section by the method previously explained, we obtain owing values:

$$328.22\,x - 164.05 = 0$$

$$x = +0^{mm}.50 \pm 0^{mm}.083$$

$$[vv] = +138.06$$

$$r_0 = \pm 1^{mm}.50$$

$$r_x = \pm 0^{mm}.083$$

$$r = \pm 0^{mm}.88$$

$$R = \pm 4^{mm}.04$$

xpress these results in words, we would say that this observer makes elevations , as he advances by $+0^{mm}.050 \pm 0^{mm}.083$ per kilometer, that the probable f a single leveling was $\pm 0^{mm}.88$ per kilometer, and that the probable error of erence of elevation between Austin and Friar's Point was $\pm 4^{mm}.04$. The nu- l work of obtaining these results is given on page 28.

E LEVELS FROM COLUMBUS, KY., TO MEMPHIS, TENN., AND FROM FRIAR'S POINT TO PRENTISS, MISS.

e two sections include about 404 kilometers, and were leveled by the same ob- , with the same party and outfit, during the same field season, and are here l as one section.

manner of doing the work was quite varied; sometimes an observer duplicated rk in opposite directions, sometimes in the same direction, either north or south, gain, two observers would level the same lines, in the same direction, or in op- directions. This section, then, furnishes us with examples of all the combina- f observers possible, and is, therefore, a valuable one for this discussion. The ork was done between November 4, 1879, and April 22, 1880. As examples of ombination are scattered along throughout the entire distance, the separate ave been numbered consecutively from Columbus and Friar's Point, the latter rs being distinguished by accents.

following exhibits in tabular form the results of leveling this section:

bservers.	Distance.	Number of discrepancies.			Sum of discrepancies.			Mean size of discrepancies.		Values of x and x'.
		+	−	Total.	+	−	Total.	+	−	
	km.				*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
idge...........	*66.7	39	7	46	+326.9	− 20.1	+306.8	+8.38	−2.87	+2.03 ± 0.18
ost............	*23.4	7	11	18	+ 37.3	− 48.2	− 10.9	+5.33	−4.38	−0.53 ± 0.35
nkee...........	*18.4	2	7	9	+ 4.8	− 36.3	− 31.5	+2.40	−5.19	−0.81 ± 0.21
Frost..........	†215.8	25	95	120	+ 92.9	−589.7	−496.8	+3.72	−6.21	+2.02 ± 0.16
Frost..........	*22.0	11	3	15	+ 76.5	− 11.4	+ 65.1	+6.95	−3.80	+1.47 ± 0.74
Yankee	†5.3	1	3	4	+ 3.0	− 29.2	− 26.2	+3.00	−8.73	+6.12 ± 1.33
—Frost........	†4.6	0	5	5	0.0	− 21.9	− 21.9	0.0	−4.38	+4.79 ± 0.71

* Leveled in opposite directions. † Leveled in same directions.

The first observer makes elevations too low as he advances by $+2^{mm}.11 \pm 0^{mm}.18$ [per] kilometer, and makes elevations lower than the second observer when leveling in [the] same or opposite directions, and also lower than the third observer when leveling [in] the same direction. We have so many observations on this point that it cannot [be] doubted that this observer's results were affected by an error which remained v[ery] nearly constant throughout the entire season, and where the error has not been eli[m]inated by his leveling in both directions, that a correction to his results is necessa[ry]. The sign of the correction is certain, and we may consider that a close approximati[on] to the amount of the correction has been obtained from the 46 equations of condit[ion] obtained from lines leveled in opposite directions. This correction applied to the p[art] between Columbus and Memphis for the lines leveled in one direction by this obser[ver] would amount to $+220^{mm}$, and to the part between Friar's Point and Prentiss $+107^{mm}$ or a total correction at Prentiss of $+327^{mm} = 1.07$ feet.

The constant error of this observer must have been independent of direction, [as] he gets the same results, as compared with the second observer, whichever direct[ion] he levels. The condition of the ground and changes of weather evidently have no[th]ing to do with the error, for it lasts throughout the entire season, and the second [ob]server when leveling over the same ground at the same time does not obtain simi[lar] results.*

The results obtained by this observer the following season between Grafton, I[ll.], and Cairo, Ill., contained no evidence of such a constant error as here shown. I[t is] evident, then, that a duplication in an opposite direction the second season, of li[nes] leveled in one direction during the first, would not have eliminated the constant er[ror] from the mean.

From this we have the practical conclusion that an observer should duplicate [his] work as soon as possible under, as nearly as practicable, the same conditions. T[he] error of this observer cannot be attributed to a settling of the rod supports, but co[uld] be explained by supposing that the rods or instrument raised a small amount gen[er]ally throughout the season.

The discrepancies of the second observer show that his errors were accident[al], which fact is also shown by the probable error of determining his personal error.

The third observer made elevations too high as he advanced, but he did not le[vel] enough lines to compensate in any appreciable degree the effect of the first observe[r's] personal error.

The fourth observer did so little work that no conclusion could safely be dra[wn] from the results, but the evidence is all in one direction.

The numerical work of obtaining the results contained in the preceding table[s is] given on pages 150 and 151. No attempt has been made to compute the proba[ble] error of the resulting difference of elevation of this section, as it is believed that t[he] formulæ for probable errors are not applicable to a large portion of the work.

PRECISE LEVELS FROM PRENTISS, MISS., TO GREENVILLE, MISS.

This section of 72 kilometers was leveled by Assistant J. B. Johnson, and all li[nes] were leveled in opposite directions. After 44.2 kilometers had been leveled with t[he] rods supported on foot-plates, stakes with nails in their tops were driven and the r[ods] supported on these for the remainder of the distance. This section has been cited [as] furnishing an example of rods settling when supported on foot-plates and rising wh[en] supported on stakes. It has, therefore, been divided into two parts, according to t[he] character of supports, and each part analyzed separately, to ascertain if the mann[er] of supporting the rods has introduced a constant error in the results.

Letting $x_{,}$ and $x_{,,}$ represent the constant error in the two parts, respectively, th[en] by the formulæ previously given we obtain

$$x_{,} = -\overset{\text{mm.}}{0.62} \pm \overset{\text{mm.}}{0.12}\ ,\ r_{0,} = \pm \overset{\text{mm.}}{2.70}$$
$$x_{,,} = +0.35 \pm 0.17\ ,\ r_{0,,} = \pm 2.79$$

These results would seem to indicate that the manner of supporting the rods h[as] introduced constant errors in the results, but the proof is not positive. An inspecti[on] of the discrepancies and residuals in the first part shows—

	m[m.]
14 negative discrepancies, whose sum is	—6[illegible]
8 positive discrepancies, whose sum is	+1[illegible]
13 negative residuals, whose sum is	—3[illegible]
9 positive residuals, whose sum is	+2[illegible]

The sum of the discrepancies, without regard to sign, is $77^{mm}.6$, and of the residu[als] $62^{mm}.9$.

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* It might be well to state in this connection that in all the work done on the Mississippi River, [the] principle of eliminating instrumental errors by equal fore and back sights has been followed, and t[hat] therefore the accumulation of errors cannot be attributed to errors of adjustment of instruments.

come $-0^{mm}.31$ and $+0^{mm}.07$, respectively, and their difference would scarcely that would be expected from their probable errors.

spicion that these discrepencies are the result of accidental errors is strength- the fact that this was the observer's first experience in this work, and also act that all his subsequent work shows occasional errors of approximately for the later errors the explanation has been offered that they were caused by of the rodmen, but as errors of reading the rod of 10^{mm} or 20^{mm} frequently d are detected in the field or in the reduction, it is quite likely that this is that these errors were made and escaped detection.

rous examples could be drawn from the note-books of this office where the of the three wires are inconsistent, and show that an error of 10^{mm} has been reading either one or two wires, with no evidence to decide which is the n uncertainty of 10^{mm}, therefore, remains in the mean of the three readings. planation of the way errors of that size are made is not confined to this or to this observer.

nclude, then, that the proof that changing the manner of supporting the rods cted the results is not sufficient. That the cumulative error was not the f motion of rod supports, would have been inferred from the results of the etween Columbus and Memphis, where two observers with rods supported tained so dissimilar results while leveling the same lines at the same time. r to explain the results obtained by the first observer there by a motion of the ports, it would be necessary to suppose that a foot plate and rod weighing in ounds, had *risen* nearly uniformly throughout an entire season. As the press- the foot plate would probably be increased by the rodman about 20 pounds, pposition is inadmissible.

ave, therefore, combined all the results in this section, and obtained the fol- values:

$$769.52\,x+205.87=0,\quad x=-0^{mm}.26\pm0^{mm}.11,\quad [vv]=744.94$$
$$r_o=\pm3^{mm}.07,\quad r_x=\pm0^{mm}.11,\quad r=\pm1^{mm}.48,\quad R=\pm8^{mm}.88.$$

PRECISE LEVELS FROM GRAFTON, ILL., TO CAIRO, ILL.

only results obtained in this section of 345 kilometers bearing upon the subject discussion were those obtained by Assistant O. W. Ferguson in the 221 kilo- south from Grafton. These results are shown on the plot on Plate III, and ce to them has previously been made. This observer made elevations too low dvanced, but the error did not remain constant, and the method here given t been applied to the results. As, during the time that he leveled the lines on the plot, he also leveled many lines to the south without duplicating them opposite direction, it is probable the difference of elevation obtained between

As the plot of the discrepancies on Plate V, shows that this error was practically constant throughout, its value has been found by the formulæ.

$$x = -0^{mm}.62 \pm 0^{mm}.11$$
$$r_0 = \pm 1^{mm}.61$$
$$r_x = \pm 0^{mm}.11$$

As it is more probable that this error was made by one observer than that the two observers made equal errors of opposite signs, the difference of elevation between Keokuk and Grafton is probably in error by 45^{mm} from this cause. The sign of the error is not determined. The numerical work of obtaining these results is given on page 157.

PRECISE LEVELS FROM CARROLLTON, LA., TO BILOXI, MISS.

The levels of this section of 140 kilometers were run by the same observers and in the same manner as those between Keokuk and Grafton. After about 60 kilometers had been leveled, the results of the two observers commenced to diverge until at the end of the line their results differed by about 50^{mm}. The same remarks are applicable to this section as the preceding one.

PRECISE LEVELS FROM CAIRO, ILL., TO COLUMBUS, KY., AND FROM MEMPHIS, TENN., TO AUSTIN, MISS.

The leveling of these sections, with the exception of about 6 miles, was all done in one direction, the observer carrying along two lines by means of two rods, used independently. There is, therefore, no information as to whether or not there was any accumulation of errors in these sections.

PRECISE LEVELS FROM GREENVILLE, MISS., TO CARROLLTON, LA.

The levels of this section of 470 kilometers were run by parties of the United States Coast and Geodetic Survey, and the method pursued was to level alternate sections in opposite directions, in order "to prevent the gradual accumulation of error, supposed to be due to running constantly in one direction" (C. S. Report, 1880, page 137). It is probable that this method prevented any accumulation of error, but it fails to give any evidence on the subject.

The following are the values of r and R, computed by the method given in "Präcision-Nivellement der Elbe," which method is in use by the United States Coast and Geodetic Survey:

$$r = \pm\ 0^{mm}.90$$
$$R = \pm 11^{mm}.6$$

PRECISE LEVELS FROM KEOKUK, IOWA, TO FULTON, ILL.

The results of all the sections previously mentioned were known before this section was leveled, although the final reductions were not quite completed.

The conclusions to be drawn from them had been pointed out in the preliminary report, and some experimental work had been done with reference to obtaining additional information upon the subject, but the results indicated that the work was not of a character to make it valuable in this discussion.

When the parties took the field they received instructions that each observer should duplicate his own work in opposite directions. In order to throw additional light on the question whether or not the accumulation of errors noticed in some of the sections was caused by a motion of the rod supports, the parties were provided with steel pins, to be used as they saw fit in supporting the rods.

A slight modification was also made in the form of the spur in which the rod terminates. This modification consisted in having the rod terminate in a plane surface, which rested on a conical surface on the foot-plates or pins, instead of terminating in a spherical surface, which rested on a concave spherical surface of larger diameter. The observers were the same as those employed in the sections Carrollton to Biloxi and Keokuk to Grafton.

On pages 158 and 159 is given a tabulation of the results obtained in this section. As the observers leveled alternate portions of the line, the numbering of the bench-marks, which is consecutive, will indicate the order in which the results occur in the line. Sometimes an observer obtained two results at the same time by using both foot-plates and pins. In the tabulation such results are indicated by an asterisk in the column of bench-marks. An examination of the table shows that the discrepancies of either observer are well distributed, both with regard to sign and amount, throughout the season's work, whether leveling on pins or foot-plates; and that the work upon the

s slightly better than that upon pins. These facts are shown by the fol-
of discrepancies:

	O. W. F., OBSERVER.				J. B. J., OBSERVER.			
	Pins.		Foot plates.		Pins.		Foot plates.	
	Discrepancies.				Discrepancies.			
	No.	Sum.	No.	Sum.	No.	Sum.	No.	Sum.
		mm.		mm.		mm.		mm.
....	41	+83.2	23	+35.8	31	+60.9	32	+71.0
....	34	−63.8	23	−51.1	29	−76.2	32	−56.5
....	75	+19.4	46	−15.3	60	−15.3	64	+14.5
....	......	1.96	......	1.89	......	2.28	......	1.99

discrepancy in all the first observer's work is +4.1mm and in the second in the whole section +3.3mm.

rkable counterbalancing of errors may partly be accidental, but is prob- to be attributed to increased care in the work. There is nothing in the shows that an accumulation of error was prevented by changing from support to the other.

ding sections include all the levels along the Mississippi River, except Fulton to connect with Lake Michigan, at Chicago, which are not yet ced. It is believed that the following conclusions can safely be drawn sults set forth in the preceding pages.

esults of leveling may be effected by cumulative errors, which vary with servers, and do not always remain constant with the same observer.

nean of several results obtained by the same or different observers may re- siderable correction.

these cumulative errors are nearly proportional to the distances leveled, cases are independent of the nature of the ground, the direction in which done, the season, or the manner of supporting the rods.

in order, as far as possible, to eliminate the effect of such errors, each ob- ld duplicate his own work in opposite directions, under the same condi-

long lines of levels, even if leveled in duplicate, should be independently

e report is submitted in hopes that it may add information in regard to d increase the accuracy of future operations. It is hoped that it may your approval.

respectfully, your obedient servant,

L. L. WHEELER.

ut. SMITH S. LEACH,
tary Mississippi River Commission.

ion of personal error of Assistant L. L. Wheeler from the results of levels from Austin to Friar's Point, Miss.

$-(n-s)=v$		$4K^2x-2K(n-s)$		v	vv	$\frac{vv}{2K}$
km.	mm.			mm.		
...3.1	+ 2.8	+ 9.61	+ 8.68	− 1.2	1.44	0.47
...2.4	+ 0.1	+ 5.76	+ 0.24	+ 1.1	1.21	0.50
...1.7	+ 2.9	+ 2.89	+ 4.93	− 2.1	4.41	2.60
...2.0	− 0.7	+ 4.00	− 1.40	+ 1.7	2.89	1.44
...2.6	+ 4.2	+ 6.76	+ 10.92	− 2.9	8.41	3.23
...2.1	+ 1.2	+ 4.41	+ 2.52	− 0.2	0.04	0.02
...2.1	− 1.1	+ 4.41	− 2.31	+ 2.1	4.41	2.10
...1.5	0.0	+ 2.25	0.00	+ 0.8	0.64	0.04
...4.2	+ 3.2	+ 17.64	+ 13.44	− 1.1	1.21	0.30
...3.4	+ 0.2	+ 11.56	+ 0.68	+ 1.5	2.25	0.66
...2.3	+ 0.8	+ 5.29	+ 1.84	+ 0.4	0.16	0.08
...4.0	+ 3.5	+ 16.00	+ 14.00	− 1.5	2.25	0.56
...1.8	− 0.3	+ 3.24	− 0.54	+ 1.2	1.44	0.90
...6.4	+ 0.8	+ 40.96	+ 5.12	+ 2.4	5.76	0.90

Determination of personal error of Assistant L. L. Wheeler, &c.—Continued.

	$2Kx-(n-s)=v$		$4K^2x-2K(n-s)$		v	vv
	km.	mm.			mm.	
(15)	2.5	— 0.8	+ 6.25	— 2.00	— 2.0	4.00
(16)	4.3	+ 4.0	+ 18.49	+ 17.20	— 1.8	3.24
(17)	1.2	— 3.8	+ 1.44	— 3.36	+ 4.4	19.36
(18)	3.2	— 1.5	+ 10.24	— 4.80	+ 3.1	9.61
(19)	5.0	+ 3.5	+ 25.00	+ 17.50	— 1.0	1.00
(20)	2.7	+ 2.2	+ 7.29	+ 5.94	— 0.8	0.64
(21)	4.0	— 2.7	+ 16.00	— 10.80	+ 4.7	22.09
(22)	1.7	+ 0.9	+ 2.89	+ 1.53	— 0.1	0.01
(23)	4.9	+ 3.8	+ 24.01	+ 18.62	— 1.4	1.96
(24)	4.0	— 0.2	+ 16.00	— 0.80	+ 2.2	4.84
(25)	1.0	+ 0.6	+ 1.00	+ 0.60	— 0.1	0.01
(26)	6.0	+ 8.7	+ 36.00	+ 52.20	— 5.7	32.49
(27)	4.7	+ 1.7	+ 22.09	+ 7.99	+ 0.7	0.49
(28)	2.5	+ 2.5	+ 6.25	+ 6.25	— 1.2	1.44
(29)	0.7	— 0.2	+ 0.49	— 0.14	+ 0.6	0.36
			328.22	+164.05	[vv] =	138.06

Normal equation:

$$328.22x-164.05=0 \qquad x=+0.50^{mm}\pm0.083$$

$$m=29 \qquad \mu=1 \qquad p=328$$

$$r_x=\frac{.6745\sqrt{[vv]}}{\sqrt{p(m-\mu)}}=\pm0.083^{mm}$$

$$R=\pm0.6745\sqrt{\frac{43}{29}\times\frac{49.47}{2}}=\pm4.04^{mm} \qquad r=\pm0.88^{mm}$$

Determination of personal error of Assistant J. A. Paige, from the results of levels Columbus to Memphis and from Friar's Point to Prentiss.

No. of line.	$2Kx-(n-s)$			v	vv	$4K^2-2K($	
3	0.8	+ 5.4	= +	7.0	49.00	0.64	+
4	2.1	+ 1.4	= +	5.7	32.49	4.41	+
9	1.4	— 4.4	= —	1.6	2.56	1.96	—
12	1.8	— 10.3	= —	6.6	43.56	3.24	—
13	0.9	+ 0.7	= +	2.5	6.25	0.81	+
14	2.3	— 4.1	= +	0.6	0.36	5.29	—
15	6.3	— 14.3	= —	1.5	2.25	39.69	—
16	1.7	— 15.0	= —	11.6	134.56	2.89	—
17	0.8	+ 3.2	— +	4.8	23.04	0.64	+
19	4.4	— 21.5	= —	12.6	158.76	19.36	—
20	8.9	— 12.3	= +	5.8	33.64	79.21	—
21	2.2	— 4.3	= +	0.2	0.04	4.84	—
22	6.1	— 5.2	= +	7.2	51.84	37.21	—
23	3.0	— 6.6	= —	0.5	0.25	9.00	—
24	2.1	— 8.7	= —	4.4	19.36	4.41	—
25	3.5	— 6.8	= +	0.3	0.09	12.25	—
28	1.3	— 1.9	= +	0.7	0.49	1.69	—
29	2.2	— 17.8	= —	13.3	176.89	4.84	—
30	4.0	— 24.5	= —	16.4	268.96	16.00	—
31	5.9	— 14.5	= —	2.5	6.25	34.81	—
32	0.6	— 1.9	= —	0.7	0.49	0.36	—
35	3.7	— 3.3	= +	4.2	17.64	13.69	—
41	1.4	— 3.8	= —	1.0	1.00	1.96	—
43	2.5	— 4.3	= +	0.8	0.64	6.25	—
44	4.5	— 5.6	= +	3.5	12.25	20.25	—
50	1.3	— 0.4	= +	2.2	4.84	1.69	—
51	5.2	+ 3.1	= +	13.6	184.96	27.04	+
66	7.9	— 8.0	= +	8.0	64.00	62.41	—
68	1.9	— 4.7	= —	0.8	0.64	3.61	—
82	2.1	— 3.4	= +	0.9	0.81	4.41	—
83	2.3	— 5.1	= —	0.4	0.16	5.29	—

etermination of personal error of Assistant J. A. Paige, &c.—Continued.

ne.	2 Kx — (n — s)	v	vv	4 K²	— 2 K (n — s)
....	1.9 — 2.4 =	+ 1.4	1.96	3.61	— 4.56
....	1.3 — 7.5 =	— 4.9	24.01	1.69	— 9.75
....	5.8 — 7.8 =	+ 4.0	16.00	33.64	— 45.24
....	1.4 — 9.7 =	— 6.9	47.61	1.96	— 13.58
....	3.9 — 19.0 =	— 11.1	123.21	15.21	— 74.10
....	3.4 — 6.6 =	+ 0.3	0.09	11.56	— 22.44
....	2.7 — 14.8 =	— 9.3	86.49	7.29	— 39.96
....	2.6 — 12.4 =	— 7.1	50.41	6.76	— 32.24
....	0.7 + 0.4 =	+ 1.8	3.24	0.49	+ 0.28
....	3.5 — 8.1 =	— 1.0	1.00	12.25	— 28.35
....	2.3 + 5.9 =	+ 10.6	112.36	5.29	+ 13.57
....	1.7 — 5.9 =	— 2.4	5.76	2.89	— 10.03
....	3.1 — 11.2 =	— 4.9	24.01	9.61	— 34.72
....	2.0 — 2.1 =	+ 1.9	3.61	4.00	— 4.20
....	2.0 — 5.7 =	— 1.6	2.56	4.00	— 11.40
			1800.39	550.40	—1118.31

l equation:

$$550.40\,x - 1118.31 = 0. \qquad x = +2.03^{mm}$$

npute prob. error of x:

$$\text{P. E. of } x = 0.6745\sqrt{\frac{[vv]}{p(m-\mu)}} = 0.6745\sqrt{\frac{1800.39}{550.40\times 45}} = \pm 0.18^{mm}$$

$$x = +2.03^{mm} \pm 0.18^{mm}$$

error of a single observation:

$$r_0 = \pm 0.6745\sqrt{\frac{1800.39}{45}} = \pm 4.27^{mm}$$

nations of personal error of Assistant B. D. Frost from results of levels from Columbus to Memphis and from Friar's Point to Prentiss.

ne.	2 K x — (n — s) =	v	vv	4 K²	— 2 K (n — s)
....	2.8x — 11.7 =	—13.2	174.24	+ 7.84	—32.76
....	4.8 + 11.0 =	+ 8.5	72.25	+ 23.04	+52.80
....	1.9 — 0.2 =	— 1.2	1.44	+ 3.61	— 0.38
....	3.1 — 3.6 =	— 5.2	27.04	+ 9.61	—11.16
....	2.3 + 2.1 =	+ 0.9	0.81	+ 5.29	+ 4.83
....	1.7 + 1.9 =	+ 1.0	1.00	+ 2.89	+ 3.23
....	4.8 + 11.0 =	+ 8.5	72.25	+ 23.04	+52.80
....	2.7 + 5.9 =	+ 4.5	20.25	+ 7.29	+15.93
....	4.3 + 2.0 =	— 0.3	0.09	+ 18.49	+ 8.60
....	2.9 — 3.0 =	— 4.5	20.25	+ 8.41	— 8.70
....	2.1 + 5.9 =	+ 4.8	23.04	+ 4.41	+12.39
....	2.2 — 2.5 =	— 3.7	13.69	+ 4.84	— 5.50
....	2.4 + 0.1 =	— 1.2	1.44	+ 5.76	+ 0.24
....	2.0 + 4.9 =	+ 3.8	14.44	+ 4.00	+ 9.80
....	1.3 + 1.9 =	+ 1.2	1.44	+ 1.69	+ 2.47
....	1.5 + 1 5 =	+ 0.7	0.49	+ 2.25	+ 2.25
....	2.0 — 11.7 =	—12.8	163.84	+ 4.00	—23.40
....	2.0 — 4.6 =	— 5.7	32.49	+ 4.00	— 9.20
			640.49	+140.46	+74.24

al equation:

$$140.46x + 74.24 = 0 \qquad x = -0.53^{mm}$$

. error of a single observation:

$$r_0 = \pm 0.6745\sqrt{\frac{640.49}{17}} = \pm 4.14^{mm}$$

. error of x:

$$r_x = \pm\frac{r_0}{\sqrt{p_x}} = \pm\frac{4.14}{\sqrt{140.46}} = \pm 0.349^{mm} \qquad x = -0.53^{mm} \pm 0.349^{mm}$$

Determination of personal error of Mr. [illegible].

No. of line.	[illegible] = v	vv	4K²	−2K(
[illegible]	[illegible]	[illegible]	+ 2.56	+
[illegible]	[illegible]	[illegible]	+ 25.00	+
[illegible]	[illegible]	0.49	+ [illegible]	+
[illegible]	[illegible]	[illegible]	+ [illegible]	+
[illegible]	[illegible]	[illegible]	+ [illegible]	+
[illegible]	[illegible]	[illegible]	+ [illegible]	+
[illegible]	[illegible]	[illegible]	+ [illegible]	−
[illegible]	[illegible]	[illegible]	+ [illegible]	−
[illegible]	[illegible]	[illegible]	+ [illegible]	+
		[illegible]	+[illegible]	+

Normal equation:

$$[illegible]x + [illegible] = 0 \qquad x = -[illegible]^{mm}$$

Prob. error of a single observation:

$$r_0 = \pm 0.6745\sqrt{\frac{[illegible]}{9}} = \pm [illegible]^{mm}$$

Prob. error of x:

$$r_x = \frac{r_0}{\sqrt{p}} = \frac{[illegible]}{\sqrt{[illegible]}} = \pm [illegible]^{mm} \qquad x = -[illegible]^{mm} \pm [illegible]^{mm}$$

Determination of sum of personal errors of Assistants [illegible] and Frost, from re[illegible] lands between Columbus and Memphis, and Friar's Point and Prentiss.

No. of line.	Kx′	− (P−F) = v	vv	K²	−K(P
42	0.7x′	− 6.2 = − 5.2	27.04	0.49	−
43	1.3	− 3.6 = − 1.7	2.89	1.69	−
49	0.9	+ 1.0 = + 2.3	5.29	0.81	−
53	1.6	−11.3 = − 8.9	79.21	2.56	−
55	1.2	− 5.5 = − 3.7	13.69	1.44	−
57	0.8	− 5.6 = − 4.4	19.36	0.64	−
64	2.2	− 9.9 = − 6.7	44.89	4.84	−
66	3.9	+ 9.6 = +15.3	234.09	15.21	+
75	1.4	− 3.3 = − 7.2	51.84	1.96	−
107	1.3	− 2.1 = − 1.1	[illegible]	1.69	−
116	2.3	− 4.4 = − 1.9	[illegible]	5.29	−
134	0.4	− 3.1 = − 2.4	5.76	0.16	−
140	1.0	−26.2 = −14.7	216.09	1.00	−
39	1.0	+ 1.3 = + 2.3	5.29	1.00	+
62	2.0	4.4 = + 2.9	8.41	4.00	
			714.22	42.78	−

Normal equation:

$$42.78x' - 62.[illegible] = 0 \qquad x' = +1.47^{mm}$$

Prob. error of a single observation:

$$r_0 = \pm 0.6745\sqrt{\frac{714.22}{14}} = \pm 4.82^{mm}$$

Probable error of x':

$$r_x' = \frac{r_0}{\sqrt{p'}} = \frac{\pm 4.82}{\sqrt{42.78}} = \pm 0.74^{mm} \qquad x' = +1.47^{mm} \pm 0.74^{mm}$$

Determination of difference of personal errors of Messrs. Frost and Stevens.

[L]ine.	$Kx' - (F - S) = v$	vv	$K^2 - K(F - S)$	
....	0.7 — 0.4 = + 2.9	8.41	0.49	— 0.28
....	1.2 — 5.9 = — 0.2	0.04	1.44	— 7.08
....	1.0 — 7.2 = — 2.7	7.29	1.00	— 7.20
....	1.1 — 3.9 = + 1.4	1.96	1.21	— 4.29
....	0.6 — 4.5 = — 1.6	2.56	0.36	— 2.70
		20.26	4.50	—21.55

[Norm]al equation:

$$4.50x' - 21.55 = 0 \qquad x' = +4.79^{mm}$$

$$\pm 0.6745\sqrt{\frac{20.26}{4}} = \pm 1.51^{mm} \qquad r_s' = \frac{r_0}{\sqrt{p_{x'}}} = \pm \frac{1.51}{\sqrt{4.50}} = \pm 0.71^{mm}$$

[Determi]nation of difference of personal errors of Assistants Paige and Frost from the results of levels from Columbus to Memphis and from Friar's Point to Prentiss.

[L]ine.	$Kx' - (P - F) = v$	vv	$K^2 - K(P - F)$	
....	2.0x' + 5.9 = + 1.9	3.61	4.00	+ 11.80
....	2.4 + 16.3 = + 11.5	132.25	5.76	+ 39.12
....	2.0 + 8.2 = + 4.2	17.64	4.00	+ 16.40
....	1.6 — 2.0 = — 5.2	27.04	2.56	— 3.20
....	2.4 + 12.3 = + 7.5	56.25	5.76	+ 29.52
....	3.0 + 15.1 = + 9.0	81.00	9.00	+ 45.30
....	4.6 + 6.6 = — 2.7	7.29	21.16	+ 30.36
....	3.4 + 3.7 = — 3.2	10.24	11.56	+ 12.58
....	0.7 — 2.4 = — 3.8	14.44	0.49	— 1.68
....	4.0 — 9.1 = — 17.2	295.84	16.00	— 36.40
....	1.3 + 0.7 = — 1.9	3.61	1.69	+ 0.91
....	2.3 — 5.4 = — 10.0	100.00	5.29	— 12.42
....	3.9 + 8.1 = + 0.2	0.04	15.21	+ 31.59
....	0.9 — 1.2 = — 3.0	9.00	0.81	— 1.08
....	1.6 + 7.6 = + 4.4	19.36	2.56	+ 12.16
....	1.0 + 2.5 = + 0.5	0.25	1.00	+ 2.50
....	1.5 + 10.3 = + 7.3	53.29	2.25	+ 15.45
....	1.2 + 7.6 = + 5.2	27.04	1.44	+ 9.12
....	1.3 + 4.0 = + 1.4	1.96	1.69	+ 5.20
....	0.8 + 7.5 = + 5.9	34.81	0.64	+ 6.00
....	1.5 — 1.3 = — 4.3	18.49	2.25	— 1.95
....	2.0 + 4.1 = + 0.1	0.01	4.00	+ 8.20
....	0.5 + 0.1 = — 0.9	0.81	0.25	+ 0.05
....	2.4 + 8.4 = + 3.6	12.96	5.76	+ 20.16
....	0.5 — 3.8 = — 4.8	23.04	0.25	— 1.90
....	3.9 + 17.6 = + 9.7	94.09	15.21	+ 68.64
....	1.4 + 9.6 = + 6.8	46.24	1.96	+ 13.44
....	2.3 — 7.5 = — 12.2	148.84	5.29	— 17.25
....	3.8 + 12.4 = + 4.7	22.09	14.44	+ 47.12
....	1.0 + 8.0 = + 6.0	36.00	1.00	+ 8.00
....	0.2 + 1.8 = + 1.4	1.96	0.04	+ 0.36
....	4.3 + 4.6 = — 4.1	16.81	18.49	+ 19.78
....	0.5 + 5.1 = + 4.1	16.81	0.25	+ 2.55
....	1.6 + 10.2 = + 7.0	49.00	2.56	+ 16.32
....	2.9 — 4.9 = — 10.8	116.64	8.41	— 14.21
....	2.2 + 1.4 = — 3.0	9.00	4.84	+ 3.08
....	1.4 + 5.5 = + 2.7	7.29	1.96	+ 7.70
....	2.2 + 3.4 = — 1.0	1.00	4.84	+ 7.48
....	1.3 + 10.4 = + 7.8	60.84	1.69	+ 13.52
....	0.9 + 5.2 = + 3.4	11.56	0.81	+ 4.68
....	1.1 + 2.3 = + 0.1	0.01	1.21	+ 2.53
....	1.5 + 0.4 = — 2.6	6.76	2.25	+ 0.60
....	1.3 + 6.1 = + 3.5	12.25	1.69	+ 7.93
....	1.6 + 5.4 = + 2.2	4.84	2.56	+ 8.64
....	1.7 + 10.7 = + 7.3	53.29	2.89	+ 18.19
....	1.6 — 2.2 = — 5.4	29.16	2.56	— 3.52
....	1.0 + 7.0 — + 5.0	25.00	1.00	+ 7.00

Determination of difference of personal errors of Assistants Paige and Frost, &c.—Continu

No. of line.	Kx′	−(P−F) =			v	vv	K²−K(P−		
110	1.0	+	9.0	= +	7.0	49.00	1.00	+	
117	1.9	−	4.5	= −	8.3	68.89	3.61	−	
118	0.9	+	8.6	= +	6.8	46.24	0.81	+	
119	0.5	+	9.1	= +	8.1	65.61	0.25	+	
120	1.4	+	5.7	= +	2.9	8.41	1.96	+	
121	2.8	+	2.7	= −	3.0	9 00	7.84	+	
122	0.9	+	8.3	= +	6.5	42.25	0.81	+	
123	2.2	+	5.3	= +	0.9	0.81	4.84	+	1
124	1.2	+	10.2	= +	7.8	60.84	1.44	+	1
125	1.3	−	1.3	= −	3.9	15.21	1.69	−	
126	1.2	+	4.7	= +	2.3	5.29	1.44	+	
127	1.0	+	2.3	= +	0.3	0.09	1.00	+	
128	1.2	+	1.5	= −	0.9	0.81	1.44	+	
129	2.3	−	4.2	= −	8.8	77.44	5.29	−	
130	0.4	−	3.4	= −	4.2	17.64	0.16	−	
131	0.6	+	1.0	= −	0.2	0.04	0.36	+	
132	0.5	+	0.7	= −	0.3	0.09	0.25	+	
133	3.2	+	12.9	= +	6.4	40.96	10.24	+	4
134	4.9	+	16.2	= +	6.3	39.69	24.01	+	7
135	4.2	+	5.6	= −	2.9	8.41	17.64	+	2
136	1.2	+	10.2	= +	7.8	60.84	1.44	+	1
137	1.2	−	1.3	= −	3.7	13.69	1.44	−	
138	3.4	+	5.7	= −	1.2	1.44	11.56	+	1
146	4.0	+	9.6	= +	1.5	2.25	16.00	+	3
147	1.0	+	4.5	= +	2.5	6.25	1.00	+	
148	0.8	−	3.7	= −	5.3	28.09	0.64	−	
149	1.3	+	0.8	= −	1.8	3.24	1.69	+	
150	0.8	+	9.8	= +	8.2	67.24	0.64	+	
151	1.0	+	1.5	= −	0.5	0.25	1.00	+	
152	0.9	+	2.0	= +	0.2	0.04	0.81	+	
153	3.4	+	5.7	= −	1.2	1.44	11.56	+	1
154	0.9	+	6.5	= +	4.7	22.09	0.81	+	
155	0.9	−	2.7	= −	4.5	20.25	0.81	−	
156	1.6	+	2.6	= −	0.6	0.36	2.56	+	
157	2.3	+	7.8	= +	3.2	10.24	5.29	+	1
158	2.0	+	3.1	= −	0.9	0.81	4.00	+	
159	5.4	+	7.1	= −	3.8	14.44	29.16	+	3
160	1.8	+	6.5	= +	2.9	8.41	3.24	+	1
161	1.0	−	7.3	= −	9.3	86.49	1.00	−	
162	0.9	+	7.4	= +	5.6	31.36	0.81	+	
163	1.2	+	6.5	= +	4.1	16.81	1.44	+	
164	2.2	+	11.2	= +	6.8	46.24	4.84	+	2
165	2.8	+	9.5	= +	3.8	14.44	7.84	+	2
34′	3.1x′	+	0.6	= −	5.7	32.49	9.61	+	
35′	2.3	−	1.7	= −	6.4	40.96	5.29	−	
36′	1.0	+	6.5	= +	4.5	20.25	1.00	+	
37′	3.1	+	5.3	= −	1.0	1.00	9.61	+	1
38′	1.0	−	2.0	= −	4.0	16.00	1.00	−	
39′	0.6	−	1.1	= −	2.3	5.29	0.36	−	
40′	1.0	+	4.0	= +	2.0	4.00	1.00	+	
41′	2.4	+	5.0	= +	0.2	0.04	5.76	+	1
42′	2.1	+	2.7	= −	1.5	2.25	4.41	+	
44′	0.7	+	5.4	= +	4.0	16.00	0.49	+	
45′	0.9	−	7.9	= −	9.7	94.09	0.81	−	
46′	1.9	+	10.9	= +	7.1	50.41	3.61	+	2
47′	2.6	+	6.5	= +	1.2	1.44	6.76	+	1
48′	2.8	−	5.5	= −	11.2	125.44	7.84	−	1
49′	2.1	+	2.7	= −	1.5	2.25	4.41	+	
50′	1.7	−	4.1	= −	7.5	56.25	2.89	−	
51′	2.1	+	6.8	= +	2.6	6.76	4.41	+	1
52′	1.8	−	2.4	= −	6.0	36.00	3.24	−	
53′	0.8	+	3.0	= +	1.4	1.96	0.64	+	
54′	1.0	+	1.3	= −	0.7	0.49	1.00	+	
55′	1.5	+	0.7	= −	2.3	5.29	2.25	+	
56′	2.2	+	5.3	= +	0.9	0.81	4.84	+	1
57′	2.0	+	5.6	= +	1.6	2.56	4.00	+	1

Determination of difference of personal errors of Assistants Paige and Frost, &c.—Continued.

No. of line.	Kx'	$-(P-F)=$	v	vv	K^2	$-(P-F)$
[illegible]'	0.8	+ 7.0 =	+ 5.4	29.16	0.64	+ 5.60
[illegible]	1.1	+ 2.7 =	+ 0.5	0.25	1.21	+ 2.97
[illegible]'	1.0	+ 3.4 =	+ 1.4	1.96	1.00	+ 3.40
[illegible]'	2.0	+15.8 =	+11.8	139.24	4.00	+ 31.60
[illegible]	3.3	+ 2.1 =	− 4.6	21.16	10.89	+ 6.93
63	1.0	+ 5.5 =	+ 3.5	12.25	1.00	+ 5.50
64	1.8	+ 3.0 =	− 0.6	0.36	3.24	+ 5.40
				3459.59	+ 524.20	+1060.34

Normal equation:

$$+524.20x' + 1060.34 = 0 \qquad x' = -2.02^{mm}$$

Prob. error of a single observation:

$$r_0 = \pm 0.6745 \sqrt{\frac{3459.59}{119}} = \pm 3.64^{mm}$$

Prob. error of x':

$$r_x' = \pm \frac{r_0}{\sqrt{p_{x'}}} = \pm \frac{3.64}{\sqrt{524.20}} = \pm 0.16^{mm} \qquad x' = -2.02^{mm} \pm 0.16^{mm}$$

Determination of difference of personal errors of Messrs. Paige and Sankee.

No. of line.	Kx'	$-(P-S)=$	v	vv	K^2	$-K(P-S)$
[illegible]	0.8	− 3.0 =	− 7.9	62.41	0.64	− 2.40
[illegible]	1.8	+15.7 =	+ 4.7	22.09	3.24	+ 28.26
[illegible]	1.9	+11.9 =	+ 0.3	0.09	3.61	+ 22.61
[illegible]	0.8	+ 1.6 =	− 3.3	10.89	0.64	+ 1.28
				95.48	8.13	+ 49.75

Normal equation:

$$8.13x' + 49.75 = 0 \qquad x' = -6.12^{mm}$$

Prob. error of a single observation:

$$r_0 = \pm .6745 \sqrt{\frac{95.48}{3}} = \pm 3.80^{mm}$$

Prob. error of x':

$$r_x' = \frac{r_0}{\sqrt{p_{x'}}} = \pm \frac{3.80}{\sqrt{8.13}} = \pm 1.33^{mm} \qquad x' = -6.12^{mm} \pm 1.33^{mm}$$

rsonal error of Assistant Johnson from results of from Prentiss to Greenville.

	$2Kx-(n-s)=v'$	$v'v'$	$4K^2-2K(n-s)$	v	vv	
.	$5.3x' + 4.1 = + 0.8$	0.64	$28.09 + 21.73$	$+ 2.7$	7.29	Rods supported on foot-plates.
2....	$6.9 + 6.3 = + 2.0$	4.00	$47.61 + 43.47$	$+ 4.5$	20.25	
3....	$2.9 - 3.8 = - 5.6$	31.36	$8.41 - 11.02$	$- 4.6$	21.16	
4....	$2.2 - 0.3 = - 1.7$	2.89	$4.84 - 0.66$	$- 0.9$	0.81	
5....	$2.0 - 0.7 = - 1.9$	3.61	$4.00 - 1.40$	$- 1.2$	1.44	
6....	$2.4 + 4.1 = + 2.6$	6.76	$5.76 + 9.84$	$+ 3.5$	12.25	
7....	$1.0 - 1.9 = - 2.5$	6.25	$1.00 - 1.90$	$- 2.2$	4.84	
8....	$6.9 + 5.3 = + 1.0$	1.00	$47.61 + 36.57$	$+ 3.5$	12.25	
9....	$5.2 + 14.2 = + 11.0$	121.00	$27.04 + 73.84$	$+ 12.8$	163.84	
10....	$1.0 + 1.0 = + 0.4$	0.16	$1.00 + 1.00$	$+ 0.7$	0.49	
11....	$9.1 + 0.3 = - 5.3$	28.09	$82.81 + 2.73$	$- 2.7$	7.29	
12....	$3.7 - 3.9 = - 6.2$	38.44	$13.69 - 14.43$	$- 4.9$	24.01	
13....	$5.3 + 10.4 = + 7.1$	50.41	$28.09 + 55.12$	$+ 9.0$	81.00	
14....	$4.2 + 0.3 = - 2.9$	8.41	$17.64 - 1.26$	$- 1.4$	1.96	
15....	$5.2 + 2.7 = - 0.5$	0.25	$27.04 + 14.04$	$+ 1.4$	1.96	
16....	$6.8 + 3.4 = - 0.8$	0.64	$46.24 + 23.12$	$+ 1.6$	2.56	
17....	$1.8 + 0.4 = - 0.7$	0.49	$3.24 + 0.72$	$- 0.1$	0.01	
18....	$0.5 + 1.8 = + 1.5$	2.25	$0.25 + 0.90$	$+ 1.7$	2.89	
19....	$3.7 + 2.0 = - 0.3$	0.09	$13.69 + 7.40$	$+ 1.0$	1.00	
20....	$1.0 - 1.5 = - 2.1$	4.41	$1.00 - 1.50$	$- 1.8$	3.24	
21....	$8.2 + 6.2 = + 1.1$	1.21	$67.24 + 50.84$	$+ 4.1$	16.81	
22....	$3.1 - 3.0 = - 4.9$	24.01	$9.61 - 9.30$	$- 3.8$	14.44	
		336.37	$485.90 + 299.85$		401.79	
	v''	$v''v''$				
23....	$3.7x'' + 4.9 = + 6.2$	38.44	$13.69 + 18.13$	$+ 3.9$	15.21	Rods supported on stakes.
24....	$0.5 - 1.0 = - 0.8$	0.64	$0.25 - 0.50$	$- 1.1$	1.21	
25....	$5.5 + 0.7 = + 2.6$	6.76	$30.25 + 3.85$	$- 0.7$	0.49	
26....	$7.1 - 5.0 = - 2.5$	6.25	$50.41 - 35.50$	$- 6.8$	46.24	
27....	$8.2 + 3.4 = + 6.3$	39.69	$67.24 + 27.88$	$+ 1.3$	1.69	
28....	$1.6 - 0.2 = + 0.4$	0.16	$2.56 - 0.32$	$- 0.6$	0.36	
29....	$3.3 - 4.4 = - 3.2$	10.24	$10.89 - 14.52$	$- 5.3$	28.09	
30....	$3.5 + 1.6 = + 2.8$	7.84	$12.25 + 5.60$	$+ 0.7$	0.49	
31....	$2.9 - 1.0 = 0.0$	0.00	$8.41 - 2.90$	$- 1.8$	3.24	
32....	$4.0 + 2.5 = + 3.9$	15.21	$16.00 + 10.00$	$+ 1.5$	2.25	
33....	$2.3 - 0.4 = + 0.4$	0.16	$5.29 - 0.92$	$- 1.0$	1.00	
34....	$6.9 - 11.8 = - 9.4$	88.36	$47.61 - 81.42$	$- 13.6$	184.96	
35....	$3.8 - 5.0 = - 3.7$	13.69	$14.44 - 19.00$	$- 6.0$	36.00	
36....	$1.7 - 4.0 = - 3.4$	11.56	$2.89 - 6.80$	$- 4.4$	19.36	
37....	$1.2 - 1.3 = - 0.9$	0.81	$1.44 - 1.56$	$- 1.6$	2.56	
		239.81	$283.62 - 97.98$		744.94	

Normal equations:

$$+485.90x' + 299.85 = 0 \qquad\qquad +283.62x'' - 97.98 = 0$$

$$x' = -\overset{\text{mm}}{0.62} \qquad\qquad x'' = +\overset{\text{mm}}{0.35}$$

Prob. error of a single observation:

$$r_o' = \pm 0.6745\sqrt{\frac{336.37}{21}} = \pm \overset{\text{mm}}{2.70} \qquad\qquad r_o'' = \pm 0.6745\sqrt{\frac{239.81}{14}} = \pm \overset{\text{mi}}{2.7}$$

Prob. error of unknown quantity:

$$r_x' = \frac{r_o'}{\sqrt{p_x'}} = \pm \frac{2.70}{\sqrt{485.90}} = \pm \overset{\text{mm}}{0.12} \qquad\qquad r_x'' = \frac{r_o''}{\sqrt{p_x'}} = \pm \frac{2.79}{\sqrt{283.62}} = \pm 0$$

$$x' = -\overset{\text{mm}}{0.62} \pm \overset{\text{mm}}{0.12} \qquad\qquad x'' = +\overset{\text{mm}}{0.35} \pm \overset{\text{mm}}{0.17}$$

Supposing no change in unknown quantity, we have the normal equation:

$$+769.52\,x + 201.87 = 0 \qquad\qquad x = -\overset{\text{mm}}{0.26}$$

$$r_o = \pm 0.6745\sqrt{\frac{744.94}{36}} = \pm \overset{\text{mm}}{3.07} \qquad\qquad r_x = \pm\frac{r_o}{\sqrt{p_x}} = \pm \frac{3.07}{\sqrt{769.52}} = \pm 0.$$

$$x = -\overset{\text{mm}}{0.26} \pm \overset{\text{mm}}{0.11}$$

Determination of relative personal equation of Assistants Johnson and Ferguson from the results of that portion of the line from Keokuk, Iowa, to Grafton, Ill., lying between temporary bench-marks 65 and 151.

B.M.	Kx'	(J—F)		v	vv	K²	K(J—F)
66	2.4x'	— 0.2	=	— 0.7	0.49	5.76	— 0.48
67	2.8	+ 2.2	=	+ 0.5	0.25	7.84	+ 6.16
69	0.8	+ 2.8	=	+ 2.3	5.29	0.64	+ 2.24
70	2.6	+ 6.9	=	+ 5.3	28.09	6.76	+ 17.94
73	3.3	+ 1.9	=	— 0.1	0.01	10.89	+ 6.27
75	4.2	— 2.0	=	— 4.6	21.16	17.64	— 8.40
78	2.5	+ 1.7	=	+ 0.2	0.04	6.25	+ 4.25
79	1.2	+ 1.5	=	+ 0.8	0.64	1.44	+ 1.80
23	2.0	+ 3.5	=	+ 2.3	5.29	4.00	+ 7.00
24	1.4	+ 1.8	=	+ 0.9	0.81	1.96	+ 2.52
82	2.3	— 0.5	=	— 1.9	3.61	5.29	— 1.15
85	2.6	+ 3.2	=	+ 1.6	2.56	6.76	+ 8.32
25	1.4	+ 1.7	=	+ 0.8	0.64	1.96	+ 2.38
87	1.1	— 0.7	=	— 1.4	1.96	1.21	— 0.77
88	1.2	+ 4.9	=	+ 4.2	17.64	1.44	+ 5.88
89	1.8	+ 3.2	=	+ 2.1	4.41	3.24	+ 5.76
91	1.6	+ 2.1	=	+ 1.1	1.21	2.56	+ 3.36
92	1.3	+ 3.6	=	+ 2 8	7.84	1.69	+ 4.68
94	0.9	+ 1.4	=	+ 0.8	0.64	0.81	+ 1.26
95	1.0	— 0.2	=	— 0.8	0.64	1.00	— 0.20
97	2.0	— 1.7	=	— 2.9	8.41	4.00	— 3.40
99	2.4	0.0	=	— 1.5	2.25	5.76	0.00
101	2.6	+ 4.8	=	+ 3.2	10.24	6.76	+ 12.48
102	2.0	+ 1.7	=	+ 0.5	0.25	4.00	+ 3.40
31	1.4	+ 0.7	=	— 0.2	0.04	1.96	+ 0.98
104	1.0	+ 1.7	=	+ 1.1	1.21	1.00	+ 1.70
106	3.4	— 4.2	=	— 6.3	39.69	11.56	— 14.28
32	0.3	+ 2.7	=	+ 2.5	6.25	0.09	+ 0.81
108	1.7	+ 0.2	=	— 0.8	0.64	2.89	+ 0.34
109	1.3	+ 3.8	=	+ 3.0	9.00	1.69	+ 4.94
33	1.3	+ 0.6	=	— 0.2	0.04	1.69	+ 0.78
111	1.4	+ 0.1	=	— 0.8	0.64	1.96	+ 0.14
113	3.0	— 2.5	=	— 4.4	19.36	9.00	— 7.50
114	1.2	+ 3.4	=	+ 2.7	7.29	1.44	+ 4.08
115	1.0	+ 2.1	=	+ 1.5	2.25	1.00	+ 2.10
116	1.1	— 3.6	=	— 4.3	18.49	1.21	— 3.96
35	2.8	+ 4.7	=	+ 3.0	9.00	7.84	+ 13.16
119	1.0	+ 1.3	=	+ 0.7	0.49	1.00	+ 1.30
36	1.4	— 2.4	=	— 3.3	10.89	1.96	— 3.36
123	3.3	+ 2.2	=	+ 0.2	0.04	10.89	+ 7.26
124	1.0	+ 3.6	=	+ 3.0	9.00	1.00	+ 3.60
37	0.7	— 1.9	=	— 2.3	5.29	0.49	— 1.33
125	1.4	+ 5.1	=	+ 4.2	17.64	1.96	+ 7.14
126	0.7	— 1.0	=	— 1.4	1.96	0.49	— 0.70
127	2.0	+ 1.2	=	0.0	0.00	4.00	+ 2.40
128	0.8	+ 0.4	=	— 0.1	0.01	0.64	+ 0.32
129	1.4	— 0.3	=	— 1.2	1.44	1.96	— 0.42
38	1.4	— 0.8	=	— 1.7	2.89	1.96	— 1.12
130	1.5	+ 4.4	=	+ 3.5	12.25	2.25	+ 6.60
131	1.0	+ 2.6	=	+ 2.0	4.00	1.00	+ 2.60
132	2.1	— 0.7	=	— 2.0	4.00	4.41	— 1.47
40	0.5	+ 2.3	=	+ 2.0	4.00	0.25	+ 1.15
133	1.4	— 1.8	=	— 2.7	7.29	1.96	— 2.52
135	3.0	+ 2.9	=	+ 1.0	1.00	9.00	+ 8.70
136	1.0	+ 4 0	=	+ 3.4	11.56	1.00	+ 4.00
137	0.8	+ 0.2	=	— 0.3	0.09	0.64	+ 0.16
138	0.9	+ 2.3	=	+ 1.7	2.89	0.81	+ 2.07
139	1.6	— 2.4	=	— 3.4	11.56	2.56	— 3.84
140	0.7	+ 2.5	=	+ 2.1	4.41	0.49	+ 1.75
141	1.6	+ 4.7	=	+ 3.7	13.69	2.56	+ 7.52
141½	0.9	+ 3.0	=	+ 2.4	5.76	0.81	+ 2.70
143	2.1	+ 3.3	=	+ 2.0	4.00	4.41	+ 6.93
145	2.5	+ 1.0	=	— 0.6	0.36	6.25	+ 2.50
146	0.5	+ 0.3	=	0.0	0.00	0.25	+ 0.15
148	2.1	+ 0.1	=	— 1.4	1.96	4.41	— 0.21
150	2.5	+ 1.3	=	— 0.2	0.04	6.25	+ 3.25
151	0.3	+ 0.6	=	+ 0.4	0.16	0 09	+ 0.18
					376.94	+ 228.74	+ 141.90

ormal equation:

$$288.74x' + 181.90 = 0 \qquad \overset{mm}{x' = -0.62}$$

$$\pm .6745\sqrt{\frac{273.24}{66}} = \overset{mm}{\pm 1.61} \qquad r_{x'} = \pm\frac{1.61}{\sqrt{288.74}} = \pm 0.$$

$$\overset{mm}{x' = -0.62 \pm}$$

Discrepancies between north and south lines of levels between Keokuk, Iowa, and
by Assistants J. B. Johnson and O. W. Ferguson.

O. W. Ferguson, observer.				J. B. Johnson, observer.			
No. of bench-mark.	Distance.	n—s		No. of bench-mark.	Distance.	n—s	
		Pins.	Foot-plates.			Pins.	F pl
1*	1.7	− 1.1	− 5.9	2*	1.4	+ 2.7	+
2*	1.8	+ 0.6	+ 4.3	U. S. 1*	0.6	− 2.6	−
6*	1.2	+ 0.1		3*	2.4	− 0.2	−
9	1.7	− 1.3		7	1.7	− 2.9	
10	1.6	+ 2.9		8	1.2	− 0.2	
12	0.8	− 0.5		U. S. 9	0.4	− 3.5	
13	1.6	+ 0.5		11	2.2	− 5.0	
17	0.9	+ 0.1		14	1.6	− 2.9	
U. S. 4	1.1	+ 0.6		15	1.4	+ 0.8	
U. S. 3	0.8	− 1.5		18	1.6	− 3.3	
U. S. 6	1.4	+ 2.7		18	1.5	+ 2.8	
22	1.7	− 0.9		19	1.5	− 3.7	
23	1.6	+ 2.8		20	1.7	− 1.2	
24	1.7	− 1.4		29*	1.5	− 2.9	−
25	0.8	+ 0.5		30*	0.6	− 0.3	−
27	1.6	− 2.9		31*	0.2	+ 0.7	−
29	1.4	− 0.1		35*	1.5	− 3.1	+
32	0.9	− 2.7		36*	1.6	+ 5.6	−
33	0.8	− 1.6		38*	0.8	− 4.5	−
34	1.4	+ 0.2		39*	0.8	− 5.3	−
U. S. 19	1.5	+ 4.3		42*	1.5	− 5.8	−
37	1.2	− 2.6		43*	1.3	+ 3.2	+
40	1.2	− 1.9		U. S. 13*	1.1	+ 2.0	+
41	1.5	+ 2.3		47½	1.1		+
44	1.6	+ 3.5		48	0.5		−
45	1.7	− 1.0		51	0.9		+
46	1.4	− 1.1		52	0.8		−
49	1.3	+ 1.2		53	0.9		+
U. S. 15	0.4	+ 1.2		54	1.4		+
50	1.3	+ 2.1		56 B	0.8	+ 1.5	
55	1.2	− 3.3		57	0.5	+ 1.5	
58	1.4	− 2.7		58*	1.0	+ 4.1	−
56 A	1.9	+ 0.6		64	0.7		+
59	1.3	− 2.3		65	1.0		−
60	1.2	− 1.3		66	1.1		−
61	1.2	− 2.1		69	1.2		+
62	1.6	− 3.0		70	1.4		−
63	0.8	+ 2.0		71	1.1		+
67*	1.7	+10.0	+ 3.3	74	1.1		+
68	0.6		+ 2.2	75	1.3		−
72	1.3		− 0.3	76	0.8		+
73	2.5		+ 3.7	77	1.3		+
78	1.3		+ 1.3	84	1.5		−
79	1.1		+ 1.0	85	1.3		−
80	0.4		+ 0.7	86	1.3		+
81	0.5		+ 1.3	87	1.1		+
82	1.5		+ 3.3	88	1.0		+
83	1.2		− 0.4	90	0.2		+
89	3.4		+ 0.6	95*	1.2	− 3.4	−
U. S. 22	0.3		+ 0.6	96	1.0	− 1.2	
92	0.1	+ 0.1		97	0.9	+ 1.7	
93*	1.1	+ 1.3	− 5.6	100	1.3	+ 1.1	
94*	0.9	+ 0.3	− 0.5	101	0.8	− 1.8	
98	1.9	+ 2.8		104	0.2	+ 0.4	
99	1.2	+ 0.8		106	1.6	− 4.5	
102	0.6	− 1.8		107	1.0	− 6.0	
103	0.1	+ 1.1		110	1.7	+ 4.0	
107	1.0	− 2.2		111	1.5	+ 1.0	
108	1.6	− 0.7		117	1.4	+ 2.2	
109	1.1	+ 0.1		118	0.9	− 3.8	

Discrepancies between north and south lines of level, &c.—Continued.

O. W. Ferguson, observer.

No. of bench-mark.	Distance.	n—s	
		Pins.	Foot-plates.
112	0.7	+ 3.6	
113	0.7	− 0.2	
114	0.8	+ 2.9	
115	1.0	+ 2.6	
116	0.5	+ 1.1	
120	1.7	+ 1.3	
121	0.6	− 2.0	
122	1.2	− 3.3	
123	1.3	− 0.1	
129	1.0	+ 3.2	
U. S. 29	0.3	+ 0.6	
130	1.1	− 0.5	
131	1.6	− 5.1	
134	1.5	− 3.1	
U. S. 31	1.1	− 0.6	
135	1.0	+ 1.6	
136	0.5	+ 2.5	
140	1.4		+ 1.6
141	1.1		− 2.4
144	1.1		− 2.5
145	0.7		− 0.1
146	1.1		+ 3.5
149	0.7		+ 0.4
150	1.3		+ 0.1
153	0.3		+ 0.2
154	0.5		− 2.9
155	0.6		− 0.3
158	1.0		− 2.6
159	0.6		− 1.1
160	0.2		− 2.0
164	1.2		− 2.5
165	1.2		+ 0.4
166	1.3		+ 3.2
171	1.4		+ 1.6
172	0.8		+ 0.5
176	2.0		− 0.1
177	0.9		− 3.7
178	0.8		− 0.7
183	0.9	+ 0.5	− 3.0
184	1.3	+ 3.7	− 4.9
189	0.9	+ 1.9	
190	1.2	+ 4.2	
192 A	2.1	− 1.8	
193	0.7	− 1.5	
196	2.9	− 3.2	
197	1.4	+ 4.5	+ 0.2
198	1.6	+ 4.2	
204	1.0		− 2.6
205	0.8		+ 1.0
206	2.0		− 1.1
209	2.3		+ 0.8
210	1.0		− 1.3
211	0.7		− 1.6
		+ 83.2	+ 35.8
		− 63.8	− 51.1
		+ 19.4	− 15.3
		+ 4.1	
Positive discrepancies		41	23
Negative discrepancies		34	23
Mean discrepancies		mm. 1.96	mm. 1.80

J. B. Johnson, observer.

No. of bench-mark.	Distance.	n—s	
		Pins.	Foot-plates.
119	1.3	+ 0.9	
124	0.6	− 0.4	
125	1.0	− 2.2	
126	0.9	− 2.2	
127	0.6	+ 1.1	
128	2.2	+ 2.5	
132	1.8	+ 1.2	
133	1.3	+ 3.5	
137	1.3	+ 1.3	
138	1.2	− 0.6	
139	1.5		− 0.6
U. S. 34	0.7		− 1.0
142	0.7		+ 0.5
143	1.2		− 2.6
35 A	0.9		− 0.3
147	0.5		− 1.4
148	0.7		− 2.9
151	0.5		− 0.7
152	1.4		+ 1.3
156	1.0		− 1.5
157	0.6		− 2.1
161	1.4		+ 3.5
162	1.1		+ 4.4
163	1.0		+ 4.5
168	1.5		− 0.8
170	1.1		+ 0.3
173	0.7		+ 1.0
175	1.8		+ 2.6
179	1.1		− 3.2
180	1.1		+ 3.9
181	1.0	+ 0.1	
182	1.0	+ 1.4	
186	0.8	− 0.3	
187	1.2	+ 0.6	
188	0.7	+ 2.0	
191	1.3	+ 4.7	
192	1.9	+ 2.1	
194	0.9	+ 2.8	
195	1.4	− 0.1	
199	1.3	+ 0.5	
200	1.2	+ 0.9	
201	0.8	− 1.3	
202	2.0		+ 3.2
203	1.0		− 0.4
207	1.4		+ 3.7
208	1.4		+ 1.0
63 A	2.0		+ 1.3
212	1.0		− 3.5
213	1.0		+ 3.6
		+ 60.9	+ 71.0
		− 76.2	− 56.5
		− 15.3	+ 14.5
		− 0.8	
Positive discrepancies		31	32
Negative discrepancies		29	32
Mean discrepancies		mm. 2.28	mm. 1.90

Discrepancies between north and south lines leveled by Assistant Paige between Columbus Memphis and Friar's Point and Prentiss.

No. of line.	[2 K]	[s—n]	No. of line.	[2 K]	[s—n]
	k. m.	m. m.		k. m.	m. m.
3	0.8	+ 5.4	43	69.9	−174.8
4	2.9	+ 6.8	44	74.4	−180.4
9	4.3	+ 2.4	50	75.7	−180.8
12	6.1	− 7.9	51	80.9	−177.7
13	7.0	− 7.2	66	88.8	−185.7
14	9.3	− 11.3	68	90.7	−190.4
15	15.6	− 25.6	82	92.8	−193.8
16	17.3	− 40.6	83	95.1	−198.9
17	18.1	− 37.4	84	97.0	−201.3
19	32.5	− 58.9	85	98.3	−208.8
20	31.4	− 71.2	86	104.1	−216.6
21	33.6	− 75.5	94	105.5	−226.3
22	39.7	− 80.7	95	109.4	−245.3
23	42.7	− 87.3	96	112.8	−251.9
24	44.8	− 96.0	99	115.5	−266.7
25	48.3	−102.8	101	118.1	−279.1
28	49.6	−104.7	130	118.8	−278.7
29	51.8	−122.5	10′	122.3	−286.8
30	55.8	−147.0	11′	124.6	−280.9
31	61.7	−161.5	18′	126.3	−286.8
32	62.3	−163.4	23′	129.4	−298.0
35	65.0	−166.7	27′	131.4	−300.1
41	67.4	−170.5	36′	133.4	−305.8

Discrepancies between results of levels by Assistants Paige and Frost from leveling betw Columbus and Memphis and Friar's Point and Prentiss.

No. of line.	[K]	[F—P]	No. of line.	[K]	[F—P]
26	2.0	+ 5.9	129	108.3	+273.7
27	4.4	+ 22.2	130	108.7	+270.3
33	6.4	+ 30.4	131	109.3	+271.3
34	8.0	+ 28.4	132	109.8	+272.0
37	10.4	+ 40.7	133	113.0	+284.9
38	13.4	+ 55.8	134	117.9	+301.1
39	18.0	+ 62.4	135	122.1	+306.7
40	21.4	+ 66.1	136	123.3	+316.9
41	22.1	+ 63.7	137	124.5	+315.6
42	26.1	+ 54.6	138	127.9	+321.3
43	27.4	+ 55.3	146	131.9	+330.9
45	29.7	+ 49.9	147	132.9	+335.4
48	33.6	+ 58.0	148	133.7	+331.7
49	34.5	+ 56.8	149	135.0	+332.5
52	36.1	+ 64.4	150	135.8	+342.3
53	37.1	+ 66.9	151	136.8	+343.8
54	38.6	+ 77.2	152	137.7	+345.8
55	39.8	+ 84.8	153	141.1	+351.5
56	41.1	+ 88.8	154	142.0	+358.0
57	41.9	+ 96.3	155	142.9	+355.3
59	43.4	+ 95.0	156	144.5	+357.9
60	45.4	+ 99.1	157	146.8	+365.7
61	45.9	+ 99.2	158	148.8	+368.8
62	48.3	+107.6	159	154.2	+375.9
65	48.8	+103.8	160	156.0	+382.4
66	52.7	+121.4	161	157.0	+375.1
67	54.1	+131.0	162	157.9	+382.5
69	56.4	+123.5	163	159.1	+389.0
70	60.2	+135.9	164	161.3	+400.2
71	61.2	+143.9	165	164.1	+409.7
72	61.4	+145.7	34′	167.2	+410.3
73	65.7	+150.3	35′	169.5	+408.6
74	66.2	+155.4	36′	170.5	+415.1
75	67.8	+165.6	37′	173.6	+420.4
97	70.7	+160.7	38′	174.6	+418.4
98	72.9	+162.1	39′	175.2	+417.3
99	74.3	+167.6	40′	176.2	+421.3
100	76.5	+171.0	41′	178.6	+426.3
101	77.8	+181.4	42′	180.7	+429.0
102	78.7	+186.6	44′	181.4	+434.4
103	79.8	+188.9	45′	182.3	+426.5
104	81.3	+189.3	46′	184.2	+437.4
105	82.6	+195.4	47′	186.8	+443.9
106	84.2	+200.8	48′	189.6	+438.4
107	85.9	+211.5	49′	191.7	+441.1
108	87.5	+209.3	50′	193.4	+437.0
109	88.5	+216.3	51′	195.5	+443.8

Discrepancies between results of levels by Assistants Paige and Frost, &c.—Continued.

No. of line.	[K]	[F—P]	No. of line.	[K]	[F—P]
116	89.5	+225.3	52′	197.3	+441.4
117	91.4	+220.8	53′	198.1	+444.4
118	92.3	+229.4	54′	199.1	+445.7
119	92.8	+238.5	55′	200.6	+446.4
120	94.2	+244.2	56′	202.8	+451.7
121	97.0	+246.9	57′	204.8	+457.3
122	97.9	+255.2	58′	205.6	+464.3
123	100.1	+260.5	59′	206.7	+467.0
124	101.3	+270.7	60′	207.7	+470.4
125	102.6	+269.4	61′	209.7	+486.2
126	103.8	+274.1	62′	213.0	+488.3
127	104.8	+276.4	63′	214.0	+493.8
128	106.0	+277.9	64′	215.8	+496.8

screpancies between north and south lines of levels, run by L. L. Wheeler, between Austin and Friar's Point, Miss.

B. M.	[K]	[s—n]	B. M.	[K]	[s—n]
U. S. 1	0.0	0.0	U. S.	21.0	+16.8
1	1.6	+ 2.8	14	23.1	+20.8
2	2.7	+ 2.9	15	23.7	+17.0
3	3.6	+ 5.8	16	25.3	+15.5
4	4.6	+ 5.1	17	27.8	+19.0
5	5.9	+ 9.3	18	29.1	+21.2
6	6.9	+10.5	19	31.1	+18.5
7	7.9	+ 9.4	20	31.9	+19.4
8	8.7	+ 9.4	21	34.4	+23.2
9	10.8	+12.6	22	36.4	+23.0
10	12.5	+12.8	U. S.	36.9	+23.6
11	13.6	+13.6	23	39.9	+32.3
12	15.6	+17.1	24	42.2	+34.0
U. S.	16.5	+16.8	U. S.	43.5	+36.5
13	19.7	+17.6			

Precise levels from Keokuk, Iowa, to Grafton, Ill.

B. M.	Distance.	S.—N.	[S.—N.]	B. M.	Distance.	S.—N.	[S.—N.]
	km.	*m. m.*	*m. m.*		*km.*	*m. m.*	*m. m.*
66	112.86	—0.2	— 0.2	115	176.76	+2.1	+52.3
67	115.61	+2.2	+ 2.0	116	177.85	—3.6	+48.7
68	116.38	+2.8	+ 4.8	35	180.63	+4.7	+53.3
70	119.02	+6.9	+11.7	119	181.60	+1.3	+54.6
73	122.29	+1.9	+13.6	36	182.96	—2.4	+52.2
75	126.51	—2.0	+11.6	123	186.24	+2.2	+54.4
78	129.02	+1.7	+13.3	124	187.26	+3.6	+57.8
79	130.26	+1.5	+14.8	37	187.92	—1.9	+55.9
23	132.30	+3.5	+18.3	125	189.28	+5.1	+61.0
24	133.74	+1.8	+20.1	126	189.99	—1.0	+60.0
82	136.00	—0.5	+19.6	127	191.95	+1.2	+61.2
85	138.59	+3.2	+22.8	128	192.72	+0.4	+61.6
25	140.02	+1.7	+24.5	129	194.10	—0.3	+61.3
87	141.07	—0.7	+23.8	38	195.45	—0.8	+60.5
88	142.29	+4.9	+28.7	130	196.95	+4.4	+64.9
89	144.08	+3.2	+31.9	131	197.93	+2.6	+67.5
91	145.68	+2.1	+34.0	132	200.00	—0.7	+66.8
92	147.02	+3.6	+37.7	40	200.51	+2.3	+69.1
94	147.95	+1.4	+39.1	133	201.87	—1.8	+67.3
*95	148.93	—0.2	+38.9	135	204.91	+2.9	+70.2
97	152.75	—1.7	+37.2	136	205.92	+4.0	+74.2
99	155.15	0.0	+37.2	137	206.74	+0.2	+74.4
101	157.80	+4.8	+42.0	138	207.62	+2.3	+76.7
102	159.76	+1.7	+43.7	139	209.24	—2.4	+74.3
31	161.18	+0.7	+44.4	140	209.93	+2.5	+76.8
104	162.18	+1.7	+46.1	141	211.52	+4.7	+81.5
106	165.62	—4.2	+41.9	141½	212.41	+3.0	+84.5
32	165.96	+2.7	+44.6	143	214.52	+3.3	+87.8
108	167.64	+0.2	+44.8	145	217.02	+1.0	+88.8
109	168.93	+3.8	+48.6	146	217.53	+0.3	+89.1
33	170.24	+0.6	+49.2	148	219.65	—0.1	+89.2
111	171.62	+0.1	+49.3	150	222.15	+1.3	+90.5
113	174.58	—2.5	+46.8	151	222.48	+0.6	+91.1
114	175.74	+3.4	+50.2				

*Between 95 and 97 there is a river crossing.

Discrepancies between north and south lines of levels run by Assistant Ferguson between Grafton and Cairo. The lines beyond T. B. M. 240 are not used because methods are changed.

B. M.	2 (distance).	S.—N.	2 (sum distance).	Sum (S.—N.).	B. M.	2 (distance).	S.—N.	2 (sum distance).	Sum (S.—N.).
20	2.2	—6.5	2.2	— 6.5	191	2.0	— 4.9	38.1	— 42.6
27	2.9	—0.7	5.1	— 7.2	192	1.2	— 1.1	39.3	— 43.7
33	1.7	+6.3	6.8	— 0.9	194	2.5	— 6.7	41.8	— 50.4
44	3.6	—4.5	10.4	— 5.4	195	2.5	— 2.5	44.3	— 52.9
45	1.7	+4.8	12.1	— 0.6	196	2.7	— 9.2	47.0	— 62.1
85	1.7	—3.3	13.8	— 3.9	197	1.8	— 3.8	48.8	— 65.9
87	2.3	—1.9	16.1	— 5.8	208	2.2	+ 0.3	51.0	— 65.6
157	1.1	—4.7	17.2	—10.5	209	2.4	— 9.3	53.4	— 74.9
160	3.0	+0.1	20.2	—10.4	217	2.5	— 5.2	55.9	— 80.1
163	3.1	—3.4	23.3	—13.8	218	2.5	— 9.4	58.4	— 89.5
28	1.1	—0.5	24.4	—14.3	232	4.7	— 7.5	63.1	— 97.0
40	2.4	—7.2	26.8	—21.5	233	0.8	— 5.7	63.9	—102.7
46	1.1	—2.0	27.9	—23.5	235	4.0	—20.2	67.9	—122.9
31	2.1	—7.7	30.0	[illegible]	[illegible]	2.1	—13.2	70.0	—136.1
51	0.6	+1.2	30.6	—30.0	[illegible]	1.8	—11.4	71.8	—147.5
173	0.7	—1.5	31.3	[illegible]	[illegible]	2.2	—12.8	74.0	—160.3
34	4.8	—6.2	36.1	[illegible]					

APPENDIX D.

REPORTS OF CHIEFS OF PARTIES, UPON FIELD WORK OF TOPOGRAPHY AND HYDROGRAPHY, 1882-'83.

1.—REPORT OF ASSISTANT ENGINEER J. A. [illegible]ERSON, ARKANSAS CITY TO GREENVILLE AND NATCHEZ [illegible] BAYOU SARA.

OFFICE [illegible]ISSIPPI RIVER COMMISSION,
[illegible]int Louis, Mo., September 15, 1883.

SIR: I have the honor to submit the [illegible] report on the field operations under my direction during the season of 1882 [illegible]

In accordance with your instructions, [illegible] party left Saint Louis on September 12, 1882, for Arkansas City, arriving at the latter point on September 15. The quarter boats Mississippi and Louisiana and the tug Frolic, which were assigned to the party, arrived on the 17th, and work was begun at once. The organization of the party was as follows: J. A. Ockerson, chief of party; topographers, B. H. Colby, N. B. Craig, J. C. Quintus, L. C. Jones, F. Felkel, G. M. Anderson, and W. Garvin; hydrographers, C. W. Clark and D. S. Flower; levelers, F. B. French and R. C. Hoyer; draughtsman, Edwin J. Jolley. E. E. Haskell was attached to the party until October 19th, when he received orders to report for duty to Assistant L. L. Wheeler at Vicksburg. F. Felkel and G. M. Anderson joined the party on October 16, and W. Garvin on October 28. R. B. Whiteford, who started out with the party, was disabled, and was ordered to Saint Louis on September 29. The laboring force was about the same as the previous season.

The topographical work began on the right bank at Arkansas City, and on the left bank at Offutt's Landing, where the work of last season ended.

The survey was completed on November 4 to Barnes' Landing, about 2 miles above Greenville, where it joins the work of Assistant G. Y. Wisner.

On the completion of this reach the party was ordered to Natchez to resume the survey and continue down the river. The party left Greenville with quarter-boats in tow of the tug Frolic on November 5, and arrived at Natchez on November 8.

The survey was completed to Bayou Sara, where it joined the work of Assistant C. M. Winchell, on February 19, when orders were received to disband the party and return to Saint Louis.

The stage of the river was unusually favorable for surveys during the entire season. At the beginning of the work there were many places which were impassable from the deposits of mud left by the previous high water, and in such cases considerable detail was necessarily omitted.

From the beginning of the season till the middle of October there was a great deal of sickness in the party. At one time one-third of the entire party were sick with malarial fevers. Of the original party, twenty were discharged before October 25, on account of sickness. Judging from this experience, it is evident that it is not safe to take the field prior to the middle of October.

There were thirty-three days of rain and fog, or a little more than one-third of the entire season.

The progress of the work is due to the hearty co-operation of my assistants, who are deserving of credit for their fidelity and energy.

TERTIARY TRIANGULATION.

The secondary triangulation was not carried over Spanish Moss Bend, and at other points so many stations had caved into the river, that a tertiary system became necessary over the entire reach above Greenville. Below Natchez the tertiary work became necessary because the data, such as azimuths and lengths of triangle sides, was not furnished to the party.

The tertiary work was always connected with the secondary stations when found, and a comparison has been made with the secondary data on file in this office. The results are given in a table below. The tertiary angles were measured with Würdemann, No. 152, reading to 10 seconds, and Gamboy, No. 2, reading to 5 seconds. Angles were read by J. A. Ockerson and B. H. Colby.

Comparison of tertiary with secondary triangulation.

Lines compared.	No. of tertiary triangles.	Tertiary lengths.	Secondary lengths.	Ratio of discrepancies.
		meters.	*meters.*	
Wallwood–Carter	34	1389.67	1389.7	1 in 46323
Winn–Olvers	10	2818.4	2819.5	1 in 2562
Wil[illegible]–Allway	18	1938.6	1939.0	1 in 4816
Island–Pullen	38	1518.6	1518.2	1 in 3796
S. W. Base–Rock Hill	58	3152.9	3152.6	1 in 10509
Leatherman–Stump	88	1547.2	1547.3	1 in 15472
Stevenson–Douglass	96	2223.8	2223.5	1 in 7412
N. W. Base–St. F. church spire	25	1389.7	1389.7	Lengths equal.

The following method was used in reading the angles. The system was laid out and the angles generally read in advance of the topographers, so that the lengths of sides and azimuths could be used to check the stadia work. The △ point was marked by a pole about 2 inches in diameter, and bearing a red-and-white flag to distinguish it from the ordinary sounding flags. A strip of white cloth was fastened around the pole near the bottom, to which the pointings were made, thus obviating errors from swaying of the pole in the wind, or from its being out of plumb. In observing, the theodolite was placed on an ordinary instrument tripod centered over the hole, after removing the pole. The angles were read three times on different parts of the limb to check errors of reading. Most of them were measured with Gamboy No. 2. No attempt was made to confine the measuring to favorable conditions of atmosphere, but angles were read whenever the target could be seen at all.

Flags can be set and the angles read over a reach of 5 miles a day. Considering the time spent in this work, the results shown are remarkably good.

In view of the desirability of having frequent checks on the stadia work, particularly where there are so many new observers, I would suggest that the topographical parties be required to locate points at intervals of not more than a mile, by means of a tertiary system of triangulation. This system should begin and end on lines of known length, so that it can be checked.

TOPOGRAPHY.

The general scope of the topographical work was the same as last season, a description of which is given in Appendix G, Progress Report of the Mississippi River Commission, 1882. The compass was used in running lines through the woods, as suggested in above report. This method was found to be quite satisfactory, and much more rapid than the transit lines used in former work.

Beyond the prescribed topographical limits there were located the outlines of bluffs, old river lakes and bayous, and the Red River from Cut-off Bayou to the Mississippi River.

HYDROGRAPHY.

Many more soundings were taken than heretofore. Besides the sections normal to the channel, soundings were taken along the line of deepest water. The latter work

was preferably done during calm weather, when the sounding boat was allowed drift along the thread of the current. The deepest water found during the season w 156 feet, the stage of river being about 27 feet below the high water of 1882. Th depth was found at two points, one near New Texas, and the other about five mil above Bayou Sara.

ORDINARY LEVELS.

The levels were based on the primary elevations of the United States Coast a Geodetic Survey. Very few of the Coast Survey stone lines were connected with, the stones could not be found. Many of them were buried below, or even with t surface of the ground, and no mark was left above the surface to indicate the locali of the bench-mark.

A new form of bench-mark was used for points situated in the woods, some distar from the river, the object being to increase the stability and make them more consp nous, so they can be easily found.

This bench-mark consisted of a flat stone, 18 inches square and 4 inches thick. T upper surface was dressed smooth, and a hole was drilled in the center, into wh a copper bolt was leaded, the end projecting a quarter of an inch above the face the stone. The stone was marked thus U S • B M This was placed three feet below surface of the ground, with the marked surface up, care being taken to have it h izontal and firm. On this stone, and centered over the copper bolt, a cast iron pi 4 inches in diameter, and 5 feet long, was placed, and the dirt tamped in around The pipe is large enough to admit a leveling rod. The top is closed with a cap, wh is fastened to the pipe by means of a bolt.

The cap is marked as follows:

The elevation of both the top of the pipe and the stone were determined.

The amount of work done is given in a table below.

TOPOGRAPHY.

Number of miles of river surveyed (above Greenville, 36; Natchez to Bayou Sara, 100)	
Average miles of river surveyed per month	
Number of square miles of topography (above Greenville, 70¼; Natchez to Bayou Sara, 250)	32
Average number of square miles per month	
Number of elevations determined	34
Average number of elevations per square mile	
Number of triangulation stations occupied	
Number of base lines measured with steel tape	
Number of stone bench-marks set	

HYDROGRAPHY.

Total number of soundings	23,
Number of sextant angles read	15,
Average distance between sections	3
Number of square miles of hydrography	
Total number of square miles surveyed	

Plate 1 shows the portion of the river covered by the survey.

CAVING BANKS.

The rate of caving in the bends between Arkansas City and Greenville during years 1880 to 1882, as determined by comparing the present position of the sh line with its position when the triangulation was done, is given in a table bel

There being no reliable data for determining the rate of caving below Natchez, this much has been omitted.

Locality.	Character of banks.	Annual rate of caving.
		Meters.
Yellow Bend 2¼ miles below Arkansas City	Clay and sand	57
Yellow Bend 3¼ miles below Arkansas City	do	14
Yellow Bend opposite Port Anderson	Sand and silt	22
Georgetown Bend ½ mile below Offutt's	Clay and sand	39
Georgetown Bend at Eutopia	do	39
Georgetown Bend at Ashbrook Point	Sand and silt	29
Rowdy Bend ¾ of a mile below Gaines Landing	Clay and sand	35
Rowdy Bend 2 miles below Gaines Landing	do	14
Rowdy Bend at Scott's Landing	do	22
Miller's Bend at Morris Landing	do	40
Miller's Bend at Tarpley place	do	28

SAND WAVES.

A minute survey was made of a sand bar near Fairview, La., for the purpose of showing the sand waves which are characteristic of all bars. The bar selected is not an extreme case. There are many which have larger and higher waves, and others which are comparatively smooth. In the latter case the waves have the appearance of a pond whose surface is ruffled by a gentle breeze.

It is evident that these waves are mainly due to the action of the water, as they are frequently found on the lower part of bars composed of silt, which is not movable by the wind. The particles on the above bar are about the size of common building sand. The crests of the waves are smooth curves, which are frequently parallel for several waves in succession.

The bluff part of the wave is on the down-stream side, and is frequently nearly vertical. The slope on the up-stream side is generally very gentle.

A plat of the Fairview Bar, which shows the waves by means of contours one foot apart, and two sections of the bar, is appended herewith. A model, showing the bar in relief, has also been prepared.

LEVEES.

ARKANSAS CITY TO GREENVILLE.

Right bank.—From Arkansas City down ¾ mile the embankment of the L. R. and M. R. R. R. serves the purpose of a levee. Here the railroad turns back, and the embankment of an old abandoned railroad continues along the river for 1¼ miles, when it disappears. One and a half miles lower down it again appears and follows along the bank of what was at one time the chute of Island 80, to Gaines Landing, the only break being a small one through which Boggy Bayou passes. At this break the levee is now about 2 miles from the river. A private levee incloses the plantation at Gaines Landing. After following along near the river for ¾ mile below Gaines the levee ends abruptly on the caving bank of Rowdy Bend. This break is about 3 miles long, reaching to a point near Scott Landing. Here the levee divides, and one portion of it runs south about half way across the point, then turns west and runs to Yellow Bayou, forming a back levee for the plantations fronting on Spanish Moss Bend, and turning the water which overflows the banks in Rowdy Bend into Bayou Maçon.

The other part of the levee follows along near the river down to the chute of Island 82, thence down the chute to river on the lower side of the point, thence along river bank again down to near Bellevue Landing. Here it turns and joins the back levee mentioned above. This line is broken in many places, one of the breaks, near Linwood, being about ½ mile long.

The levee begins again ½ mile below Bellevue and 600 meters from the river, and runs down till it joins the old levee about ½ mile above Luna. The old levee extends above this juncture about a mile. From Luna the levee is continuous for about 4½ miles, when it is again cut off by a caving bank. At Point Chicot Landing it appears again and runs directly back from the river for a distance of 600 meters, where it is again broken, and does not appear till beyond the limits of this survey.

Left bank.—From Offutt's Landing the levee runs almost directly across to a point 1½ miles above Argyle Landing, leaving Ashbrook and Woodstock Points outside. It is 550 meters from the river at the lower part of Miller's Bend. From the point where it strikes the river above Argyle it turns and runs down at a distance of ¼ mile from the river in the deepest part of the bend, and continues down behind Island 83 to Greenville.

NATCHEZ TO BAYOU SARA.

Right bank.— om Vidalia the levee runs down near river bank to Whitehall. Here it turns back a runs around Natchez Island, coming near the river again near Crother's Plantation. From latter point it runs about 400 meters from the river till it reaches the head of Sai Catherine's Bend, where it turns and runs directly across Esperance Point to the Pecan plantation, about ½ mile above Green's Landing. A small levee then follows along near the river for a distance of a mile and there ends. From the latter point to Ashley Landing there is no levee. Then comes a piece, badly broken, aggregating 1¼ miles long. Below this there is no levee till we reach Fairview, where there are several patches, with a total length of about 1½ miles. At Home Place we again find a small levee 1 mile long, and small patches may be found down as far as Bougère. Then there is no levee till we reach Union Point, where it starts back along the old river bank behind the batture, and continues for about 3 miles. Then comes a break extending to Black Hawk. From this point the levee follows along behind a cypress swamp for about 3 miles, and finally, after numerous breaks, is lost entirely and no more levee is found till Red River Landing is reached. From latter point it runs along near river to Smithland, where it turns back along bank of Old River touching the river again at Fleta above New Texas. There is an old levee about miles long lying along ba out opposite Tunica Island and 1 mile from the main river.

From Fleta the levee river to Morganza crevasse, where the "Grand Levee" is brok 00 meters. Below this the levee is continuous down to the en t Coupée, except the "Scott crevasse," which was nearly close right bank aggregate about 34 miles.

Left bank.—There is levees on the left bank till we reach Tunica Island. From you Sara there was formerly a levee. This section was know istrict. But little of the levee now remains. There are small pa od Landing down to Sebastopol, where it disappears entirely, an en of it till we reach a point opposite Morganza. From the la s down to Hardwick ditch, opposite Stuart's Landing. It b wood yard and runs down to within half a mile of the mouth e it turns back towards the hills.

There are private levees ust below Hutchins Landing is a piece about 1¼ miles long, which tation from the hills to the river bank.

Behind the Corena plant rview, is a levee 2½ miles long, which serves to keep out the back water.

Allaway plantation has a small front and back levee 1½ miles long. Artonish plantation above Stamp's Landing, has about 1 mile of levee. Langside plantation has a levee along lower side of Clark's Lake, which is about 1 mile long. On the Angola plantation a levee starts in about opposite Smithland and follows along about a mile from the river for a distance of about 4 miles, when it runs into the bluffs. The locations of the above-described levees may be seen on Plate 1, accompanying this report.

STONE LINE SECTIONS.

In the Report of Mississippi River Commission, Appendix G, page 162, a discussion of river-bank profiles is given. A continuation of the same study has been made to embrace that part of the river lying betweem Arkansas City and Donaldsonville.

The sections of the banks do not differ materially from those heretofore published until we reach a point near Baton Rouge (Stone line No. 11). From this point down the levees are very close to the edge of the bank, and the land outside of the levee is very often three or four feet higher than that on the inside. This indicates a deposit of that amount since levees were built. Sometimes this deposit reaches nearly to the top of the levee.

The sections of the river bed grow gradually narrower and deeper as we approach Donaldsonville.

Respectfully submitted.

J. A. OCKERSON,
Assistant United States Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission

PORT OF ASSISTANT ENGINEER C. M. WINCHELL, LAKE PROVIDENCE TO WARRENTON AND BAYOU SARA TO DONALDSONVILLE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 22, 1883.

I have the honor to make the following report concerning the work done by lrographic and topographic party under my charge during the field season of d 1883:

edience to written instructions from you, I left Saint Louis on September 26, r Lake Providence, La., to assume charge of the party which had been organd taken the field under the direction of Assistant G. Y. Wisner. I arrived at rovidence October 3.

ions to this date the party had been engaged in filling up gaps in the last year's which had been skipped on account of the high water of 1882.

survey was continued with the assistants assigned as follows: Hydrography, Russell and C. N. Roberts; topography, left bank, G. W. Wood and F. B. ; topography, right bank, J. A. Paige and H. W. Kerr; levels, J. C. Camand Moses Greenwood. Recorder J. T. Desmond plotted most of the topo- field-notes, the field-plats being completed by the topographers on rainy days other times when they could not work to advantage in the field.

tant S. L. Beaumont did some topography and assisted in the plotting until ty began work at Bayou Sara, January 8, when he was made hydrographer, sell having resigned December 28.

tant J. C. Cammack died in New Orleans December 31, and Recorder C. N. s carried the levels on the left bank from Port Hudson to Donaldsonville, La. nt A. L. Arner reported for duty January 12, and was assigned to assist the raphic party.

Cammack was an enthusiast in his profession, a conscientious worker, and exally well informed in the various branches of engineering. By his untimely he Commission lost a valuable assistant, and his messmates a beloved friend. highly esteemed by all who knew him.

rate of progress of the work was materially lessened during October and No- by sickness, nearly every member of the party suffering from fever or chills er. B. R. Morgan, steward, died October 13 and was buried on land of Judge at Hays' Landing, Miss. There were very few new cases of sickness after the od frosts, but 26 men, out of a party of sixty, were discharged on account of s before November 15.

survey was based on a system of secondary triangulation previously executed United States Coast and Geodetic Survey, all intermediate points for delineat- topographic features being located by transit and stadia, the stadia courses checked by connecting with triangulation stations. A continuous line of levels n down each bank of the river and numerous points determined to aid the aphers in developing the five-foot contours. The levels are referred to the is datum plane of the Mississippi River Commission, and are checked by con- with precise bench-marks established under direction of the United States and Geodetic Survey.

e-line bench-marks were established once in about three miles of river, con- of four stones (two on each side of the river), set in line at right angles to annel of the river, the stones furthest back being usually 1,000 to 1,200 meters e river bank. These lines were so arranged as to pass through a triangulation on one or both banks of the river, the distance back being determined by The elevations of the bench marks were checked by duplicate levels. Two of bench-marks were used, the ones nearest the river being granite posts three ng and six inches square, set in the ground with their tops projecting about t above the surface. The bench-marks set farther from the river consisted of ones 16"x 18"x 4", with copper bolt leaded into hole in center of upper surface. one was set 2½ feet below the surface of the ground, and an iron pipe five feet arefully centered over the copper bolt and held in position until the hole was and ground tamped around the pipe. The top of the pipe is covered with a hich can be removed to admit the leveling rod so that the stone can be reached t disturbing the earth around or over it. The elevations of the top of the cop- t in the stone, and of the top of the cap on the pipe, were both determined in s.

style of bench-mark is preferable to the stone post, because, having a much r base and being lighter, its value will not change so much by settling; the ne being entirely beneath the surface, will not be in so much danger of acci- disturbance as the stone post which projects above the surface; and, lastly, it more easily found, the iron pipe projecting 2½ feet above the ground.

ooded country the compass and stadia were used for locating points of eleva- develop the five-foot contours. By using the compass, woods and swamps examined more rapidly and with less cutting than by the usual method of

[illegible] thus considerably reducing the expense of the survey. When the[illegible] [illegible]e connected with the regular stadia courses, or with triangulatio[illegible] [illegible] as a[illegible] [illegible]ds, it was found that the work closed with an error of less than [illegible]

[illegible] survey [illegible] completed to Big Bayou, about eight miles below Vicksburg, whe[illegible] A[illegible]ant L. L. Wheeler's party began work, December 22. The tug Mignon, whi[illegible] had become disabled, was laid up, and the party was detained at Vicksburg unt[illegible] January 1, 1883, waiting for a boat to move us to Bayou Sara, La.

In obedience to your instructions the party started for Bayou Sara as soon as th[illegible] iron launch which had been assigned to the party was repaired sufficiently to mak[illegible] the trip.

Work was begun at Bayou Sara January 8, six days having been consumed in get[illegible] ting there from Vicksburg. We were delayed on the way by fog and by the wheel o[illegible] the launch getting loose, which made it necessary to hoist her out of the water an[illegible] repair her. A new hub was cast for the wheel at Baton Rouge, but the boiler leake[illegible] so badly that the tug was of very little use the rest of the season. The tug Froli[illegible] was assigned to the party a short time, which enabled us to get good soundings i[illegible] the channel below Plaquemine, where they could not well have been obtained fro[illegible] the six-oared cutter, at the then existing high stage of river, on account of the grea[illegible] depth and strong curren[illegible]

Below Bayou Sara th[illegible] [illegible]ks were not set so far back from th[illegible] river, because the bank[illegible] [illegible], the rate of change in position of th[illegible] river being much less t[illegible] [illegible]rg.

The survey was completed [illegible] [illegible]e, and connection made with the Coa[illegible] Survey topography March 1[illegible] [illegible] was discharged, and the assistants wh[illegible] were retained returned to th[illegible] [illegible]nis. The quarter-boats Tennessee an[illegible] Pioneer, the tug Frolic, and [illegible] [illegible]ere turned over to Captain Daft, of th[illegible] tow-boat Baker, and his rec[illegible] [illegible] same.

A full description of the [illegible] [illegible]e working parties, the number of me[illegible] required for each party, and [illegible] [illegible]arrying on the work in detail, is give[illegible] in the Report of the Mississip[illegible] [illegible]ion for 1882.

The season's work may be summari[illegible] [illegible]llows:

Miles of river surveyed	1[illegible]
Square miles of topography	3[illegible]
Square miles of hydrography	[illegible]
Total area surveyed ....square miles	4[illegible]

Discrepancies between precise and ordinary levels.

Between P. B. M's.	Distance.	Discrepancies.	Observer.
	Miles.	*Feet.*	
No. 112 and 128	8¾	+0.194	J. C. Cammack.
No. 128 and 137	5½	−0.017	Do.
No. 137 and 140	1½	−0.195	Do.
No. 140 and 150	5½	−0.042	Do.
No. 150 and 162	15	−0.144	J. C. Cammack a[illegible] M. Greenwood.
No. 162 and 171	5	−0.043	M. Greenwood.
No. 171 and 179	4	−0.042	Do.
No. 179 and 184	2½	−0.064	Do.
No. 184 and 188	2	−0.077	Do.
No. 188 and 197	5	−0.100	Do.
No. 197 and 207	4½	−0.007	Do.
No. 207 and 211	4½	−0.084	Do.
No. 211 and 225	7½	−0.039	Do.
No. 38 and 37	5	+0.071	Do.
No. 37 and 36	3½	+0.051	Do.
No. 36 and 35	6	−0.076	Do.
No. 35 and 34	9	+0.064	Do.
No. 34 and 33	5	−0.078	Do.
No. 33 and 32	6½	+0.043	Do.
No. 31 and 29	1¾	−0.074	C. N. Roberts.
No. 29 and 28	1	+0.090	Do.
No. 28 and 27	3¾	−0.030	Do.
No. 27 and 26	4¼	−0.116	Do.
No. 26 and 25	7	−0.014	Do.
No. 25 and 24	5	+0.023	Do.
No. 24 and 23	5¾	+0.138	Do.
No. 23 and 22	2¼	−0.163	Do.
No. 22 and 21	6½	−0.136	Do.
No. 21 and 20	4¼	+0.010	Do.
No. 20 and 19	3¾	−0.062	Do.
No. 19 and 17	6¾	+0.030	Do.

The sum of these discrepancies is —0.869 feet for a distance of 159 miles.

Discrepancies between right and left bank ordinary levels.

Locality where compared.	Distance.	Discrepancy.
	Miles.	*Feet.*
ar	7	0.221
anding	3½	0.018
Landing	6	0.199
l Landing	11	0.167
son Landing	4½	0.1[illegible]9
Landing	6	0.130
Landing	6	0.111
's Point Landing	10½	0.219
a	4½	0.160
ig Bayou	4½	0.100
Pleasant Landing	12	0.028
f Profit Island	2½	0.278
an's Landing	8	0.189
st Landing	3	0.130
on Landing	3½	0.004
t's Point	5	0.113
ood Landing	3½	0.100
mine	7½	0.122
Hope	4½	0.036
Pleasant	4	0.014
Landing	2¼	0.004
rove Landing	7	0.092
n Island	5	0.005
d Landing	4	0.194
onville	8	0.046

HIGH-WATER MARKS.

rovidence	Well-defined mark on tree opposite Lake Providence, La	1882	114.98
anding	Nail in large oak tree	1882	111.53
o	do	1880	109.49
No. 97	Well defined mark on Mr. Zach. Leatherman's house, about one mile below Arcadia Landing.	1882	110.45
n's Bend	On steps of Morancy's house, back of levee	1882	102.25
Tiele	Mark cut on corner of gin-house in front of levee	1882	105.05
's Point	On steps of dwelling three miles below Young's Point Landing	1882	99.62
ickey	On United States gauge	1882	47.60
mine	Mark on tree two miles above Plaquemine	1882	39.00
n Hope	Nail in cottonwood tree at landing	1882	39.00
Do	do	1880	35.40
Gabriel's Church		1882	37.65
Goula	Well-defined mark on warehouse	1882	37.35
d Landing	Mark on warehouse established by Gen. J. Thompson	1874	36.12
sonville	Marks cut on northwest corner of market-house by Gen. Jeff. Thompson.	1862	35.21
Do		1869	33.73
Do		1874	35.18

Table showing surface slope of river as determined by this survey.

	Distance.	Slope per mile.	Vicksburg gauge-reading.	Rising or falling.
	Miles.	*Feet.*		
Providence to head of Island 95	6.7	0.70	11.50	Falling.
of Island 95 to Hays' Landing	3.5	0.49	9.2	Stationary.
Landing to Wilton	6.8	0.40	8.9	Do.
to Chotard	10.8	0.54	9.0	Falling.
rd to Omega	8.3	0.26	8.8	Stationary.
to Helpino Landing	7.0	0.55	11.2	Rising.
o to Nebraska Landing	4.5	0.36	13.5	Do.
ska Landing to King's Point	5	0.19	12.6	Falling.
Point to head of Warrenton T. H	5.5	0.16	11.2	Do.
Sara to Kelson Landing	12.8	0.14	*15.2	Rising.
Landing to Lobdell's Landing	12.5	0.13	*14.5	Stationary.
l's Landing to Baton Rouge	10	0.12	*18.7	Rising.
Rouge to Manchac	10	0.12	*24.1	Do.
ac to Forlorn Hope	14	0.12	*27.5	Do.
n Hope to Bayou Goula	7.6	0.14	*26.6	Stationary.
Goula to Donaldsonville	19.5	0.12	*30.4	Rising.

*Baton Rouge gauge.

l quality of the work accomplished is due in a great measure to the
cy of my assistants, to whom I desire to express my thanks for the
ul manner in which they performed their duties.
fully, your obedient servant,

C. M. WINCHELL,
United States Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

3.—REPORT OF ASSISTANT ENGINEER L. L. WHEELER, WARRENTON TO NATCHEZ.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 5, 1883.

SIR: I have the honor to submit the following report upon the operations of the party in my charge during the season of 1882–'83.

The work assigned to the party was to make a topographical and hydrographical survey of that portion o ying between Warrenton and Natchez, Miss. The survey was or at least three-quarters of a mile on each side, and in all c es. It was also to include old cut-off lakes, sloughs, bayous, pographical features within a distance of ten miles of the rive..

The party left Saint Louis the tober 16, 1882, and went on board the quarter-boa s Illinois and Kent , the following day. The boats were taken in tow by the steamer O 21, and arrived at Vicksburg October 28. Two days were spent in coal, &c., on board at Vicksburg, and the boats were towed down to ber 31.

Assistant Engineer E. E. H sick soon after the party took the field and was obliged to return to Sai istant Engineer H. B. Wood and Alex. E. Kastl were detailed for eys near Arkansas City, and joined the main party about the mi ssistant Engineer O. W. Ferguson and Recorder E. K. Woodwa y December 4. Samuel Fitzhugh was promoted from rodman t 1883. The party, as finally organized consisted of Assistant Engi , O. W. Ferguson, H. B. Wood, A. H. Weber, J. W. Dorst, O. A. stl, and A. N. Milner, and Recorders Fred. Morley, E. K. Woodward, jr., and Sam el Fitzhugh, with the necessary complement of men.

The field-work commenced November 1 on the triangle side "Last-Big Bayou," about seven miles below Vicksburg, and continued until February 22, 1883, when the work was completed to Natchez.

The following day instruments, charts, note-books, &c., were packed and sent by express to Saint Louis, and the party disbanded, the assistants returning to the office.

The party was therefore engaged in field-work 114 days, 16 of which were Sundays, one an observed holiday, and on 14 the weather was such that no field-work could be done. Field-work was therefore done on 83 days, on many of which, however, only part of the day was suitable for work.

The length of main river surveyed was 93 miles, embracing 217.2 square miles of topography, and 63.3 square miles of hydrography, or a total area of 280.5 square miles surveyed.

The survey was based upon a system of triangulation and a line of precise levels executed by the United States Coast and Geodetic Survey, the results of which were furnished from that office. The survey was made in the following manner:

1st. A line of levels was run on each bank, which determined the elevations of triangulation stations, sounding-stakes, stadia-stakes, stone-line bench-marks, water gauges, high-water marks, water surfaces, &c. The levels on the right bank were checked by the precise levels, and those on the left bank by reciprocal leveling across the river. The two lines also mutually checked each other by frequent determinations of water surfaces on opposite sides of the river. All elevations were referred to the Memphis datum plane, which is a plane 225 feet below the reading 34.16 on the Memphis gauge. The leveling was performed by Assistants Dorst and Kastl.

2d. A stadia line was run on each bank, checking frequently as to azimuth and distance upon triangulation stations and intersections on distant signals, and as to elevations upon the line of levels run on each bank.

The principal topographical features along the river bank, including landings, gauges, lights, sounding-stations, &c., were located when the shore line was run. The topography back from the river was taken by lines run back for that purpose. Where the country was wooded lines were cut back from the river three-fourths of a mile in such a direction as would best determine the topography. The locating of

rees, lakes, bluffs, bayous, &c., when beyond the limit of topography, was done y stadia lines connecting with the main lines. The topographical work was done y Assistants Darrow, Ferguson, Weber, Milner, and Recorder Woodward.

3d. The hydrography consisted of lines of soundings taken normal to the stream very 400 meters, and a line of soundings taken longitudinal to the stream. The soundings were taken with a 22-pound tallowed lead, about every third sounding being located by sextant angles between signals on the banks. A sounding line of Italian hemp was first used, but was discarded and a cotton line used instead.

Assistant Wood and Recorder Morley performed the hydrographical work, and also materially aided in the other work of the survey.

4th. The points located by the topographical parties were plotted on protractor sheets to the scale 1:10000, the sketching, contours, &c., being put in by the observers when field-work could not be done. The plotting was done by Assistant Orrman.

5th. All notes were reduced in the field, and all note-books indexed.

6th. The points of the survey were marked on the ground by the usual lines of marking-stones, the positions and elevations of which were determined, and descriptions of which were made in a book kept for that purpose.

My thanks are due to the assistants and recorders for their hearty co-operation and interest in the work. Assistants Darrow, Ferguson, and Wood gave me valuable assistance aside from their regular duties, and deserve special mention for the interest shown in the general progress of the party.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

4.—REPORT OF ASSISTANT ENGINEER H. B. WOOD, UPON RESURVEYS IN FRONT OF CREVASSES.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, September 15, 1883.

SIR: I have the honor of submitting to you the following report on hydrographic work above Arkansas City, completed during the months of October and November, 1882.

The special object being to ascertain the effect of large breaks in levees upon the river bed during the great spring flood of 1882, four reaches in the immediate vicinity of said breaks were selected for hydrographic observations, all of which were located in that portion of the river surveyed by the party in charge of Mr. J. A. Ockerson, assistant engineer, during the winter season of 1881–82, just before the flood. The first reach extended from Malone's Landing, near the foot of Island No. 66, to Australia; the second, from Riverton to the head of Ozark Island; the third, from Bolivar to Cypress Creek; and the last, from Mound Place to Arkansas City.

The party consisted of two assistant engineers, pilot, steam engineer, fireman, cook, leadsman, and two rodmen, and was provided with the tug Eva, of Helena, two skiffs, and camping outfit.

To re-sound the sections as located by the previous party required that the stone lines should be found, and where no △ stations or other landmarks of prominence served to identify the other sections, a stadia line was run, and the positions of former sections marked. Accordingly, with some few exceptions, the re-sounded sections were identical with those previously established.

The water surface was connected at frequent intervals with established benches referred to the Memphis datum, and a constant gauge record kept during the progress of the work.

In the first reach, from Malone's Landing, thirty-two sections were re-sounded, covering a distance of about sixteen miles. These cross-sections have been plotted, together with the corresponding ones of the previous year, and their areas approximately measured with the planimeter, the results being tabulated herewith. A very small amount of filling-in below the breaks occurred here. By the annexed table of compared areas of cross-sections, it will be seen that an average fill has taken place, making each section about 2,200 square feet less in area than before the flood, not counting sections that were above or below their former position.

In the second reach, from Riverton, seventeen sections were re-sounded, covering about nine miles. Here each section averaged about 11,000 square feet less in area than formerly.

In the third reach, from Bolivar, where eighteen sections were re-sounded in a distance of ten miles, each section averaged 8,400 square feet less in area than when sounded the previous year.

om Mound Place, where nine sections were re-sounded in a dis- ch section averaged 23,800 square feet less in area than before

* * * * *

The followi oximate crevasse discharges for the several reaches were meas- ured by Assist gineer J. B. Johnson:

	Cubic feet per second.
First reach, Lake Cl arles and Pushmataha Breaks	15,000
Second reach, River on Break	107,400
Third reach, Bolivar Breaks	128,250
Fourth reach, Mound Place Break	20,660

The above survey occupied from October 10, 1882, to November 10, 1882, during which time seventy-six sections were resounded, covering forty miles of the total distance of one hundred and forty-five miles to Arkansas City. At the conclusion of the work, the party proceeded to Vicksburg, and joined the party in charge of Mr. L. L. Wheeler, Assistant Engineer, then located at Moore's Landing, according to your orders.

Very respectfully, yo

HENRY B. WOOD,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Com

Table showing approximate areas of c a common water-level both before and af 82.

FROM MALO) AUSTRALIA.

Section.	Area before flood.		Difference.	Remarks.
	Square feet.	*Square feet.*	*Square feet.*	
Stone line No. 38	62,550	97,550	....	Cut out by chute 66.
16	84,200	84,100	− 100	
17	77,100	68,100	− 9,000	
18	81,000	64,000	−17,000	
19	71,550	69,100	− 2,450	
20	67,150	60,900	− 6,250	
Stone line No. 39	60,000	78,400	+18,400	
25	66,800	61,800	− 5,000	
26	56,450	63,250	+ 6,800	
27	52,000	59,550	....	410m below old sect.
28	61,550	66,500	+ 4,950	
29	48,700	38,500	−10,200	
30	52,750	57,000	+ 4,250	
31	45,200	41,900	− 3,300	
32	49,100	44,400	− 4,700	
29 (chute 68)	14,850	13,850	− 1,000	
Ft. chute	15,250	19,000	+ 3,750	
33	54,950	49,100	− 5,850	
34	84,400	77,050	− 7,350	
35	78,050	75,550	− 2,500	
36	71,500	78,650	+ 7,150	
37	74,850	72,850	− 2,000	
38	61,650	58,550	− 3,100	
39	61,600	55,550	− 6,050	
40	62,350	56,800	− 5,550	
41	61,000	51,000	−10,000	
42	49,100	50,000	+ 900	
△ Id. 69	55,400	64,000	....	Below old sect.
44	66,000	73,000	....	Do.

howing approximate areas of cross-sections below a common water-level both before and after the flood of 1882—Continued.

FROM RIVERTON TO HEAD OF OZARK ISLAND.

Section.	Area before flood.	Area after flood.	Difference.	Remarks.
	Square feet.	*Square feet.*	*Square feet.*	
	65,300	69,800	+ 4,500	
	74,050	64,850	− 9,200	
	70,550	43,100	−27,450	
	87,100	66,400	−20,700	
iver.	109,400	91,900	−17,500	
	71,300	90,100	+18,800	
	50,000	63,150	+13,150	
	92,000	65,600	−26,400	
	92,550	74,150	−18,400	
	68,200	65,750	− 2,450	
	75,350	57,400	− 7,950	
	65,250	56,450	− 8,800	
	92,200	69,100	−23,100	
to Angle 22	12,000	84,600		In pocket below old sect.
to ⊙ L118	109,000	79,700	−29,300	
Pt.	169,050	158,450	−10,600	

FROM BOLIVAR TO CYPRESS CREEK.

	52,500	46,800		Below old sect.
er.	12,150	11,000	− 1,150	
	82,650	48,800		300ᵐ below.
	75,350	51,850	−23,500	
	92,150	63,000	−29,150	
	79,800	70,150	− 9,650	
	74,250	68,100	− 6,150	
	70,100	59,750	−10,350	
l.	58,200	62,100	+ 3,900	Midstream.
y Pt	57,950	45,650	−12,300	
	4,100	2,700	− 1,400	Old River, Catfish T. H.
	35,250	32,900	− 2,350	
	53,550	45,650	− 7,900	
	87,650	60,400	−27,250	
	66,700	56,000	−10,700	
ne No. 58	75,950	73,600	− 2,350	
	81,850	87,100	+ 5,250	
l Luck	62,550	68,500	+ 5,950	
	68,450	64,250	− 4,200	
	72,500	53,900	−18,600	

FROM MOUND PLACE TO ARKANSAS CITY.

	60,600	71,200	+10,600	
	94,500	66,150	−28,350	
	100,700	67,150	−33,550	
	106,700	56,550	−50,150	
	79,600	64,550		200ᵐ above old sect.
	102,000	88,800	−13,200	
	122,350	90,000	−32,350	
line No. 63	103,550	83,600	−19,950	

APPENDIX F.

REPORT OF AS[illegible] ENGINEER E. S. DAVIS UPON THE FIELD-WORK AND RESULTS OF TRANSALLUVIAL LEVELS.

SAINT LOUIS, MO., *June* 21, 1883.

SIR: I have th[illegible] [illegible]or to submit the following report on the work of trans-alluvial leveling.

The scheme for [illegible] work contemplated nine sections, located at the following-named places, [illegible] [illegible]hich have been run, except No. 3:

1. From the [illegible] ippi River, at Island No. 13, east and west to land above overflow.
2. From the [illegible] hickasaw Bluff west to land above overflow.
3. From Memphis west to uplands beyond the Saint Francis River, on line of Memphis and Little Rock Railroad.
4. From Helen[illegible]
5. Up Cypress [illegible]
6. From Grand [illegible] [illegible] Bayou Maçon Hills across the cut-off to land above overflow.
7. From Lake Providen[illegible]
8. From Grand Gulf we[illegible] Island.
9. From Fort Adams w[illegible]; thence two branches, one across Bayou Bœuf, and one acro[illegible]

The location of No. 8 wa[illegible] [illegible]ulf to Saint Joseph.

The line contemplated fr[illegible] season been omitted, with the expectation of running it after wa[illegible] [illegible]ns had been made impracticable by the presence of water in the s[illegible] [illegible]ppened, however, that this line has been submerged when work o[illegible] [illegible]een abandoned, and it yet remains to be done.

The work has occupied t[illegible] following table gives the amount done each season; also the d[illegible] [illegible]rogress. The time given each season includes the time from le[illegible] date of disbanding the party:

Season.	Distance.	Time.	Average daily rate.
	Miles.	*Days.*	*Miles.*
1880–'81	62	150	.41
1881–'82	52	104	.50
1882–'83	164	174	.97

About 20 per cent. of the time spent in the field has been occupied in traveling from Saint Louis and between lines.

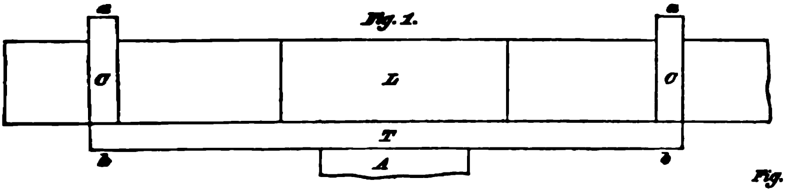
Over each line levels in duplicate and a traverse have been run. All streams crossed have been gauged roughly; elevations of high-water marks have been taken where they could be found. An azimuth has been observed at the inland end of each line except No. 5.

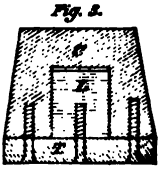
During the first season (1880–'81), Mr. Hunter Stewart assisted me, he running the traverse and I the levels. A transit and stadia were used in running the traverse, the stadia being used to measure all distances. An ordinary level and target-rod were used in running the levels.

During the first part of this season the levels were checked by running between benches a second time. During the latter part of the season the levels and check levels were run at the same time, the following method being employed: After the rod had been read in the usual position, it was inverted and held on the same point as before, and another set of readings taken. This method of checking levels will be discussed later. During the second and third seasons a combined level and transit was used.

The combination was made by fastening the essential parts of a Stackpole level to the limb of a Würdemann transit.

The device for making the combination is very simple and inexpensive, as shown by the following sketch:





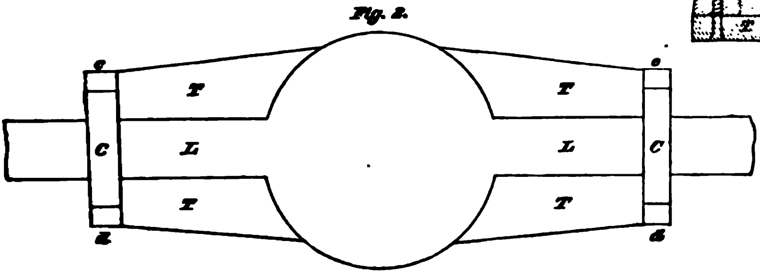


Fig. 1 is a vertical projection of a part of the instrument.
L is the bar of the level.
T is the bar of the transit.
A is the transit axis.
C and C are the collars used to hold the two instruments together.
Fig. 2 is a horizontal projection of the same parts.

Fig. 3 is a right section through the collars and shows how the parts are fastened together. When a transit was needed for azimuth observations, the screws shown in Fig. 3 were taken out, the collars and level bar removed, and the transit wyes fastened on the transit bar by the same screws. It took only a few minutes to make this change.

By the use of the combined instrument one observer was enabled to run the levels, check levels, and traverse at the same time.

As a level the combination worked admirably, and the results of azimuth observations indicate that it worked well as a transit, although the vernier plate was a little below the plane of the limb, caused by the weight of the level attachment.

When the vernier plate was brought up to the plane of the limb the spindle had a little play in its socket, which was not desirable in the level; therefore the spindle was allowed to sink far enough into its socket to prevent the play.

There was no means of causing the telescope to revolve in a vertical plane, at the same time keeping the plane of the limb horizontal. However, the necessity for reading angles with the telescope inclined did not occur very often; when it was necessary, it was accomplished by setting the instrument up so that one of the foot or supporting screws would be in the plane in which it was desirable to revolve the telescope, then the foot screw was used for inclining the telescope. By exercising due care only a small error is introduced in this way.

The telescope used contained three horizontal cross-wires, all of which were read when practicable. It frequently happened, however, that one or the other of the outside wires could not be read. The middle wire and one of the outside wires were always read. Distance tables were computed for all of the intervals, so that distance from the instrument to the rod could always be determined. Self-reading metric rods were used.

Angle or transit stations were taken as far apart as the rods could be seen. The rods used on these stations were straight poles covered with strips of black and white cloth.

The distance between transit stations was obtained by taking the sum of the distances measured between them.

The turning points and level stations between transit stations were as nearly on line as practicable.

The following sketch and explanation will show the method:

T P T' P' L P'' T''

T, T', and T'' are three consecutive transit stations.

Suppose the instrument to be at T'; then T'' is located as to direction by the angles read at T'. The turning point P' is put on line T' T''; the instrument is then moved to L and set up on line by ranging in with T' and P' and the turning point P'' put on line L T''. The rods at P' and P'' are read, the instrument is moved to T'', and the rod at P'' read; then the distances T' P', P' L, L P'', and P'' T'' are known and the distance T' T'' is equal to their sum.

For the levels two rods were used, so that at every instrument station the back and fore sights were taken on different rods. Referring to sketch above, when instrument is at T' one rod is at P and the other at P'; after completing readings, instrument is moved to L, the rod held at P for last setting is now carried to P'', and so on. By having two rods very little time is lost in waiting for rodmen. By the time the instrument is set up at L the rodman has had time to walk from P to P'' and is ready to be put on line.

LEVELS AND CHECKING.

The instrument being set up between two turning points, the rods were first held with their zeros on the points, and the readings recorded. Then the rods were inverted and held on the same points as before and another set of readings recorded in the same book and immediately below the first set.

The line run with inverted rods serves as a line of check levels. Wooden pegs were used for turning points, and were driven down nearly flush with the surface of the ground, so that elevations of turning points are practically elevations of the ground.

A copy of a page of my note-book is given to illustrate the method of keeping the notes and making the computations.

An examination of the notes will show that the method employed gives two independent lines of levels, the readings on any one rod for the two positions being entirely different, except when the middle wire reads at the middle of the rod.

Station.	S.	O.	B. S.	E.	H. of I.	F. S.	Int.	Dist.	O.	Vernier I.	Vernier II.	Remarks.
------	B	B.P's	1.280	36.420	37.800	1.380						
	F	90	1.257	36.362	------	1.431						
			1.128	------	------	1.282						
			.261	------	------	.265						
			1.464	†36.420	†34.380	1.577	.261	25.9				
			2.176	†36.259	------	1.890	.266	26.3				
			2.305	------	------	2.170						
			.261			.262				° ' "	° ' "	
40	B	80	1.748	36.262	37.702	1.870	------	------	39	14 19 00	194 18 00	Large timber and very thick underbrush.
	F	120	1.300	36.164	------	1.028	------	------	41	208 32 00	28 32 00	
			1.258	------	------	1.370	------	------	------	83 44 00	263 44 00	
			.490			.500				277 56 00	97 56 00	
			1.694	†36.259	†34.328	1.361	.4895	48.4	490	83 30 00		
			1.851	†36.162	------	1.814	.3005	48.4	300	277 46 00		
			2.173	------	------	2.060						
			.489	------	------	.501						
------	B	160	1.740	36.144	37.527	1.796						
	F	161	1.371	36.198	------	1.319						
			1.018	------	------	------						
			.722	------	------	.387						
			1.693	†36.142	†34.083	1.728	.722	71.1				
			2.059	†36.197	------	2.114	.3865	75.2				
			2.415	------	------	------						
			.722	------	------	.386						

The figures in columns 1, 2, 3, 4, 7, 10, 11, 12 and 13 are the original notes, except the intervals written under each set of readings in columns 4 and 7; the other figures are reductions.

NOTES AND REDUCTIONS.

An inspection of the notes will show the manner of keeping the field records.

Only the mid-wire readings are used in reducing the heights of instrument and elevations, the reductions for rod inverted being marked (†).

Rod in first position, back sights are plus.

Rod in first position, fore sights are minus.

Rod inverted, back sights are minus.

Rod inverted, fore sights are plus.

e readings of the outside wires are used for determining distances.
e intervals are taken out and placed beneath the sets of readings to which they ig. In the eighth column the mean intervals are placed opposite readings for ind rod, the back-sight interval being placed first. In the ninth column the diss are placed opposite the proper interval.
course objections may be raised to this method of checking levels.
might be said that any lack of adjustment of the instrument and local disturb s would affect both lines alike, or in the same direction, and it is granted that is the case. However, errors arising from these sources would not be likely to ence the results beyond the errors of discrepancy allowable in this class of work, ially when care is taken to keep the instrument in good adjustment, and to keep and fore sights equal. I feel perfectly confident in saying that this mode of king levels would detect any error caused by a blunder in reading the rod. Again, ght be said that the observer, knowing the length of the rod, would know what econd set of readings should be, the sum of the readings of any wire in the two ions of the rod being equal to the length of the rod, and that the second set of ings might be vitiated by any error that might have been made in the first set. think, however, that an error from this source would hardly occur, unless the rver intentionally computed what the second set of readings should be, and reed them as observed readings.
will of course be admitted that this method saves a great deal of time, the only tional time required for checking a line of levels being that necessary to take a od set of readings at each instrument station.
ere is still another advantage of the system, to which I desire to call attention. e is sufficient data given when all the wires are read, to enable one to correct any r that might have been made in any reading.

MAPS.

e traverse of line No. 1 was plotted on Manilla paper, scale 1:10000; the profile plotted on cross-section paper, scale 1:60, and the whole transferred to tracing h: the traverse and profile of lines 2 and 4 were plotted on protractor sheets, horial scale 1:10000, vertical scale 1:60, and the whole transferred to tracing cloth. traverse of lines 5, 6, 7, 8, and 9 was plotted on protractor sheets, scale 1:10000, their profiles plotted on tracing cloth, scale 1:60. The profiles of surface of high er of 1882 have been plotted on lines 2, 5, 6, 7, 8, and 9; the profile of high water of has been plotted on line No. 4. All the lines, traverse and profile, have been ted on paper; horizontal scale, 1:100000; vertical scale, 1:120.
ll the reduced maps, except that of line No. 1, show the profile of surface of high er of 1882. The map of line 1 shows the surface of high water of 1882 at several s, obtained from the answers to a set of questions sent to persons residing along ection.
he high-water profile for 1882, plotted on line No. 4, was reduced from the higher profile of 1867, plotted on the large-scale map by taking the difference of the h waters of 1867 and 1882 at Helena, and making the profiles parallel. The higher profiles for the other lines were plotted from high-water marks taken while rung the sections.
he above-named maps and profiles are herewith respectfully submitted as a part his report.
he time occupied in completing this work has been much greater than was at first icipated. However, the nature of the country through which the sections were taken in connection with the fact that the first two seasons were very unfavora- will account, in some measure, for the slow rate of progress.
he country through which the sections were run is mainly uninhabited, and is vily timbered. This made a great deal of clearing of lines necessary, which greatly arded the progress of the work.
he almost entire absence of roads made the transportation of camp equipage a ious difficulty even when the swamps were dry; when the swamps were wet the iculty was very much increased; several bridges and rafts have been built in order cross streams. It has been necessary on several occasions to abandon all camp ipage except what could be carried by my men, on account of the impossibility etting pack animals through the swamps
ery little time has been lost on account of sickness; in fact, the health of my ty has been better than could reasonably have been expected.

Very respectfully, your obedient servant,

E. S. DAVIS,
United States Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

APPENDIX F.

REPORTS UPON, AND RESULTS OF, RIVER GAUGINGS AT VARIOUS POINTS ON THE MISSISSIPPI AND OHIO RIVERS.

1.—AT CLAYTON, IOWA, AND PADUCAH, KY.—W. G. PRICE, ASSISTANT IN CHARGE.

CARROLLTON, LA., *May* 10, 1880.

LIEUTENANT: In accordance with your order of April 26, 1883, I have the honor to submit the following report on the work of observing discharge at Clayton, Iowa, and Paducah, Ky., and on methods of measuring the discharge of rivers.

OBSERVATIONS AT CLAYTON, IOWA.

In accordance with orders received from you, I arrived at Clayton, Iowa, on October 12, 1880, and proceeded to make a reconnaissance of the Mississippi River in the vicinity of the mouth of the Wisconsin, for the purpose of finding the most favorable location for a discharge section. There was some delay in making the selection, but the party got well started by the 25th of October, and the work was carried on without serious interruption till October 25, 1881. Until the breaking up of the ice on March 29, 1881, all the velocity observations were measured with the meter. After the ice stopped running, April 12, 1880, observations were taken with rod-floats, used in connection with the plant.

During the entire season 222 velocity observations were made, of which 85 were with the meter and 137 with rod-floats. Besides the regular velocity observations for discharge, there were taken 36 sets of vertical observations.

The balance of the work comprised:

53 sets slope observations.
28 sets longitudinal soundings.
40 sets sediment observations.
10 sets dredgings.

The results of this work were published in the Report of the Commission for 1882, page 133.

OBSERVATIONS AT PADUCAH, KY.

Arrived at Paducah November 29, 1881, and made observations of discharge from this time till November 26, 1882. During this time 215 discharges were measured, of which 27 were with rod-floats and 188 with the meter and plant. In addition to these velocity observations there were 208 verticals taken. A few of the observations were taken partly with rods and partly with the meter, but this was only an occasional occurrence.

The results of this work, as computed in the office of the commission, are appended to this report.

METHODS OF MEASURING THE DISCHARGE OF RIVERS.

Method with double floats.

I think these floats do not give the mid-depth velocity, owing to the effect the current has on the upper float and connecting wire. The upper float is also affected by the wind. Observers are supposed to use a very fine wire to connect the floats, but as this causes much trouble by breaking, a strong string is usually put in, and this catches too much water. For this reason the measurement would be too great except where there is a strong up-stream wind, when it might be too small. Measurements of vertical curves of velocity with double floats in an up-stream wind show a much greater decrease of velocity near the surface than the same measurements with the current meter.

The mid-depth velocity is not always a mean velocity. I think it varies with different sections and with different stages of water, being from 1 to 4 per cent. greater than the mean. At Paducah, Ky., during the year 1882, it was about 4 per cent. most of the time, being a little less at low water. At Carrollton during this year's observations it has been 4 per cent.

For timing floats a stop-watch is used, and I think they cannot be depended upon

unless in the hands of a careful engineer who has the mechanical skill to keep them in order.

There is no check on any of the observers, one of whom being a careless man will spoil the accuracy of the work. The shore observers may work with their instruments out of adjustment; they may miss the float but, give the signal as though all was right; or the floats, to save labor, may not be adjusted to mid-depth, and the chief of the party may not know it.

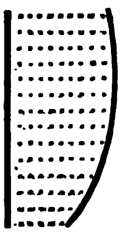
Method with rod-floats.

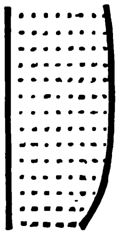
When these floats are observed from the shore, as with double floats, there is no check on any one of the observers. Careless observers will let the float project too much out of water so that it is affected by the wind. It is impossible to run floats nearer than one or two feet of the bottom, and where the sand waves are three feet high they are liable to be over three feet from the bottom most of the time. In deep places they often do not reach to mid-depth.

As the vertical curve of velocity varies very much with different sections, and also at different points on the same section, it is impossible to make a formula which will reduce the observed velocity to a true mean. For this reason when the floats do not reach nearly to the bottom they may not be as accurate as the double floats. At Carrollton, La., where the water is over 100 feet deep, it would not be easy to run floats reaching to mid-depth, and as the velocity at three-fourths of the depth is frequently found to be as great as it is at mid-depth or the surface, the observed velocity of a float reduced by Francis' formula would be far from correct.

At Paducah, Ky., the discharge was measured once a week during a part of the year by both rod-floats and the meter. The floats were run at the same stations and at the same time that the meter was running. The apparatus for running the floats was attached to the stern of the catamaran, which was anchored. The floats were timed by a good stop-watch, which was kept in good order, and it was stopped and started automatically by electricity. During the time these measurements were taken the river fell from about a medium stage to low water. At first the rod-float discharges were the greatest, but when the river had fallen much lower they were less than those taken with the meter. When the rod-float discharges were the greatest the vertical curves of velocity taken with the meter were like Fig. 1, and when they were less they were like Fig. 2.

Fig. 1. *Surface.* *Fig. 2.*





Bottom.

This showed that the observed velocity of the floats had not been reduced enough at first, and afterwards too much, though the same formula (Francis') was used all the time.

The method of running rod-floats from an anchorage with an automatic electrical apparatus for timing them is far more accurate than that with observers on shore, and the only part not checked is the reading of the stop-watch, and this should be tested at least twice a day by comparison with an ordinary watch.

Method with current meter.

In this method the man who has charge of the field-work can see that every part is done correctly. An ordinary watch can be used for timing the meter, so there is no error from this source.

It has been supposed that the meter measurements are too great, as it takes in all the oscillations of the current. Observations at Paducah, Ky., a report of which was forwarded on October 10, 1882, show that the horizontal oscillations of the cur-

rent are so small they hardly increase the registrations at all, while another obser-vation at Carrollton, La., the result of which was given in my report of April 20, 1883, shows that the vertical oscillations do not increase the measurements by the meter.

If the meter is a good machine and in the hands of a careful observer, I think it cannot fail to give correct results, while the methods with floats have been in use for a long time, and have been carried to as great perfection as possible, and yet do not give perfect results.

The method with the meter has been greatly improved during the last three years, and it was not till this year, after I had made a good many changes, that I became satisfied with the apparatus in use.

Experience shows that the only meter which will work in water which carries leaves and grass, is one with a wheel which turns like the Ellis. But the Ellis meter was not constructed with a knowledge of the difficulties it would have to contend with in the Mississippi. Owing to the particles of sand in the water the contact would not always work, and the bearings of the wheel were ruined in a short time. Small pieces of drift striking the light wheel bent or broke it, and sometimes carried it away. Repairs and new ratings were required very often. The apparatus for using it was not perfect. The insulated wire would break; the electric connection would fail, and it would be almost impossible to find where the trouble was. But the apparatus has been greatly improved, so that it is now no trouble for an ordinary boatman to manage it. A meter has been constructed which overcomes the old difficulties, and which requires no more attention than simply to be oiled occasionally.

The meter at Carrollton, La., has not been taken apart, or received any attention except to oil it, in nearly three months, and it cannot be seen that it is worn in the least, or is not just as perfect a machine as when it was constructed. The contact has never failed, and the register has never stopped except when the insulated wire was worn out.

The ratings of this meter do not vary more than one-tenth of 1 per cent., and I think that this variation is the fault of the observers. It is my experience that it requires a great change in the amount of friction with which the wheel turns, to make 1 per cent. variation in the rating.

Comparison of methods.

On the Lower Mississippi, at high water, a float will pass over the 200-foot section in less than 30 seconds. If 26 floats are run (and I believe that is about the usual number), the velocity will be measured just 13 minutes during each survey, which would require about four hours. Now, if the meter was used to take a discharge, in four hours it would have been measuring all the pulsations of the current during about 200 minutes.

A float passing over the 200-foot section in 30 seconds measures the velocity of the water only in its immediate vicinity, while the meter running only 30 seconds would measure the velocity of a line running through a 200-foot block of water.

Suppose that the observed velocity of a float could always be reduced to a true mean, and that the meter always measures the velocity correctly, it would require more than 20 floats to equal the accuracy of a 10-minute run of the meter; and at two stations at Carrollton it is necessary to run the meter 20 minutes in order to get an average velocity.

Cost of different methods per month for large rivers:

Method with double-floats or rod-floats:

One assistant engineer	$13
One recorder	9
Two leadsmen, at $55	11
Four boatmen, at $45	18
Total	51

Method with current meter:

One assistant engineer	$13
One engineer of launch	9
One steersman	5
Two boatmen, at $45	9
One steam launch	10
Total	**46**

For small rivers where a wire anchorage can be used:

Method with double-floats:

One assistant engineer	$130
One recorder	90
One leadsman	55
Two boatmen, at $45	90
Total	365

Method with rod-floats or the meter:

One assistant engineer	$ 130
Two boatmen, at $45	90
Total	220

The above is the force required to measure the discharge. If the work is to be computed in the field, one recorder will be required in addition to the force given for each method, though the work could be partly computed without him. Data taken with the meter are much the easiest to compute.

CONCLUSION.

I think the method with the current meter is the most accurate and reliable, and for large rivers it is the cheapest. For small rivers the method with rod-floats is nearly as cheap as the method with the meter.

For small rivers where a wire anchorage can be used, the method with rod-floats is much more accurate than the method with double-floats observed from the shore; but in a large, deep river I doubt if the rod-floats are as accurate as the double-floats.

I recommend the following method for measuring the discharge of rivers:

Location of section.

The section should be located in a straight reach if possible and not very near a tributary.

The section at Paducah, Ky., was located just below the mouth of the Tennessee, and the Tennessee water being warmest, and therefore lightest, spread over the Ohio water; and as the Tennessee current was much the slowest, there was a slow surface current and a swift undercurrent; and these currents were not parallel, but ran at an angle of about 20°; this caused a great deal of trouble. When the section was laid out in November the currents were all right; the trouble did not begin till the next June.

Method of locating section.

The section line should be made at right angles to the average direction taken by at least twenty rod-floats. The floats should be started from points not over 150 feet apart and about 100 feet above a preliminary section line taken at right angles to the shore line. The floats must be started from an anchored skiff; and with a sextant set at 90°, a line at right angles to the direction taken by the float should be staked off on shore. A mean of all these right-angle lines will be the best section line.

If the section is not a very good one the current on one side of the river may not run parallel with the current on the other side; in this case it might be best to make an angle in the section line.

Method of locating soundings and meter stations on section line.

Erect a line of signals on shore at right angles to the section line and up the river from it; make the length of the signal line one-fourth the width of the river. The signals must all be 25 feet apart, except the first six, which must be only 5 feet apart; make the width of the signal cloth 1 foot, and the height about 3 feet. Every fifth signal of those 25 feet apart should be double in height, so as to distinguish it from the others.

An ordinary sextant, or a cheap one made after the plan accompanying this report, must then be set at an angle of 14° 02′. This is an angle in a right-angled triangle, such that the base is four times the perpendicular; then every 25 foot space covered by the sextant will equal 100 feet out on the section line, and every fraction of 25 feet will equal such a fraction of 100 feet out. It is easy to read the distance in this way to within 1 or 2 feet. The sextant should be tested every morning by measuring with it the known distance across the river.

Location of velocity stations.

uld be measured at at least 18 stations; that is the number now La. The velocity stations should be near together where the curve , and farther apart at other places. In order to save labor in com- s should be located at the same distance from the base line every day; ... two figures of the distance should be 00, 20, 40, 60, or 80.

In a ... where the wire anchorage cannot be used, the velocity stations should be fix diagonal range lines on shore and above the section. These range lines should ... oss the section line at a sharper angle than 60°, and the nearer 90° it is the better.

Method of holding catamaran at the station.

Where the wire anchorage cannot be used, the catamaran should be lashed to the side of a launch id kept steady at the station by the pilot and engineer; great care being taken that he run of the meter begins and ends just on the section line.

The wire anchorage.

In a river which do the catamaran should be held in position by a wire anchor ve the section line.

The cross-wire shou wire, and should be made in links 80 feet 2 inches long; th wrought-iron rings 2 inches in diameter; this makes the ation 80 feet, and allows 4 inches for the sag of the wire; his is about the right amount.

The cross-wire mu ation by an anchor wire running upstream to a rock weigh the length of the anchor wire must be five times the dep

A machine for p the wire should be used; it should be placed on a platfo project 4 feet ahead of the catamaran skiffs; this platform mus

The direction in which ken across the anchorage must be reversed every time. If t the wire cannot be run twice in the same direction without e direction is always reversed, it will last a long time. When n used some time, it is best to double the cross-wire; during ably be necessary to raise the cross-wire every day to preven under the sand waves.

Method of using the meter.

The meter should be lowered from the stern of the catamaran by two No. 10 iron wires, one of which should be graduated to feet, and marked at every 10 feet by a red or white piece of cloth tied round it; the wire must be graduated by soldering to it a close winding of iron-thread wire, which should not be over $\frac{1}{100}$ of an inch in diameter. It requires about one hour for a party to graduate a wire in this way, and if properly done it will last three months. The other wire is the safety wire, and it has the insulated wire wound around it; it is necessary that the insulated wire be wound around the other, as if it is only tied to it, it will vibrate in the water and break in a short time where it is tied. The safety wire should be renewed occasionally to insure against losing the meter. These wires should run over large wooden pulleys 18 inches in diameter; small iron pulleys will break the wire in a short time.

The electric circuit is formed by two wires, one of which is the iron graduated wire; the electricity passes from this to the iron reel on the catamaran, and is taken from the shaft of the reel by three brass springs which press against a copper band which is soldered around the shaft; the other wire is insulated, and is wound around the iron safety wire which runs off the other reel; the insulated wire passes down to the shaft of the reel, and out through a groove under the bearing to another copper band which is insulated from the shaft by pine wedges driven under it; three springs press against this band the same as on the other reel; two or more springs are necessary, as one will fail to carry the current occasionally.

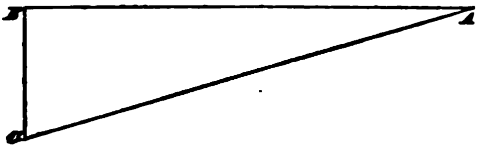
The meter frame is allowed to turn both horizontally and vertically. It is fastened to the iron rod one foot above the weight; the rod should be three-fourths of an inch in diameter. The weight is linked to the rod so that the vane keeps it parallel with the current.

Integrations with the meter.

If integrations are to be taken with this apparatus, they must be taken in both directions, top to bottom and bottom to top, and a mean of the two used.

In the right-angled triangle A B C, let A B equal the distance the water runs while

neter is moving from the top to the bottom, and B C equal the depth of the water; the line measured by the meter will be A C.



e meter must be lowered at such a slow rate that the line A B will be very long roportion to B C, so that it will nearly equal A C.

Mid-depth velocities.

taking the velocity at mid-depth, the meter must first be lowered to the bottom the sounding read on the wire; divide this sounding by 2 for the mid-depth. ng to the sag of the wire down stream, this sounding is greater than that taken h the lead-line, and must not be used in calculating the discharge.

Sounding the section.

he section should be sounded just before or just after the measurement of velocity, ept where a wire anchorage is used; in that case the section can be sounded at the e time with the measurement of velocity.

he soundings should not average over 45 feet apart. The soundings should be read both leadsman and recorder.

f an ordinary lead-line is used, it should be tested as follows: Just as soon as the ndings are finished, fasten the lead on the ground and tie a spring balance to the l of the line; give the line one quick pull and fasten it; make the pull just equal the pull which the leadsman gives the line when he raises it to take the sounding; n measure the line and correct the soundings accordingly; remember that if the is too short, the soundings are too great. With a 16-pound lead and 100 feet of t, the pull is about 26 pounds.

Method of reading gauge.

When the river is rough the gauge should be read with an instrument, a plan of ich is inclosed. The instrument is clamped at an even tenth of a foot on the gauge; n the distance from the clamp to the water is read on the graduated plate which s up in the center. A small hole near the bottom of the pipe lets in the water ich lifts the air-tight float and graduated plate. When the waves are 6 inches high gauge can be read with this instrument to within one or two-thousandths of a t.

Method of measuring discharge when the river is frozen over.

When the river is covered with ice the meter must be put down through holes, and apparatus, a plan of which is inclosed, should be constructed for the purpose.

t is a house on a sled and contains a stove, which is fed from the outside, a fuel t, a battery box, and two reels for lifting the meter, the handles to the reels being ned from the outside. It is large enough for one man only, and should be made as ht as possible. The meter is lowered through a trap-door; one reel carries a standing re with heavy weight, and the other carries a smaller wire with the insulated wire ound around it, which is fastened to the top of a piece of gas-pipe; the meter fastened the gas-pipe slides up and down on the standing wire.

The electric current is carried by the insulated wire and the wire around which it is und. It is taken from the hub of the reel by copper bands and springs, the same are used on the catamaran; the standing wire should be graduated to feet.

Method of reading the gauge through the ice.

Cut a hole where the water is not over 4 or 5 feet deep, and drive in a stake with a nd top; let the top of the stake be about 8 inches above the bed of the river; de- mine the elevation of the stake by leveling to a bench-mark; read the elevation the water by measuring from the top of the stake to the surface of the water, using graduated rod with a piece of board on the end, as shown in the plan accompanying s report. It will be necessary to melt the ice from the rod after each reading.

Rating of meter.

The meter should be rated in a lake of still water, which should not be less than 5 feet deep; put the meter on an iron rod so that it is free to swing in any direction; fasten the rod in front of a skiff so that the meter will be some distance under water; if the meter is too near to the surface or to the skiff, a good rating will not be obtained. Draw the skiff by means of a rope at different velocities over a base of 200 feet. Examine the meter occasionally to see if the connecting wires have not become twisted around the iron rod, so as to hold the meter out of line with the current.

All the ratings of a meter should be the same, unless the wheel has been bent.

All the methods, instruments, and every part of the apparatus given in this report have been used by me for a long time, and are known to work well. The drawings accompanying this report were made by Mr. M. K. Bowen, recorder.

Respectfully submitted.

W. G. PRICE,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge observations, Paducah, Ky.

This section, of which a sketch and profile are given below, was located 2¼ miles below the mouth of the Tennessee River. Parallel base lines, one on each shore, were fixed, and the observations taken on a line at right angles to these; the distance between bases was 4,100 feet. Velocity was taken at sixteen or seventeen stations on this line, and soundings for section were made at intervals varying from 50 to 100 feet.

Above the stage of 41 feet the Illinois bank was overflowed for a limited width. As this bank was covered with a dense growth, the shore-line at high stages was placed where the current became imperceptible.

At a stage of 43 feet, on the Kentucky side, the water reached the top of an old earthwork behind which was a depression, the bottom of which was at the 34-foot level. The water width and area of this depression were neglected in the field computations, but were included in the revision made in the office.

A peculiar feature of this section is that at this point the waters of the two rivers are still but imperfectly mingled, the flow of the Tennessee overlying that of the Ohio for some distance out from the Kentucky side. In consequence, the velocities taken by the meter at mid-depth, in this part of the section, being those of the underlying current (Ohio), which is here swifter than that of the Tennessee, are higher than the mean velocities indicated by integration measurements, while the corresponding rod-float velocities are regularly less than the mean. In the field computations this anomaly was disregarded, but in the office computations, these mid-depth velocities were corrected by the use of coefficients deduced from the velocity curves.

In the tables the mean gauge reading is given for noon, while the computations are based upon the gauge height at the mean time of observation.

Scour and fill is the difference between the change of area as observed and that computed from the change of gauge; scour is recorded as plus, fill as minus.

The datum stage was taken at 50 feet, and an area below this datum assumed. "Area below datum" for each discharge was obtained by combining the scour or fill with the preceding datum area.

The direction of the wind is recorded by the "clock-face" method, XII being upstream. Force is estimated on a scale of 1 to 10.

The computations from the beginning of observations to August 12 were made in the field; after that date in the office.

E. H. TWINING.

NOTE.—The discharge at this point is subject to the control of such varying conditions, that the plotted sheet shows frequent departures from a normal curve.

The conditions of control are—the stage of water at the mouth of the Ohio, that of the Upper Ohio, and that of the Tennessee.

* * * * * * *

Discharge observations at Paducah, Ky.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cubic feet.			°	°		
1881. Dec. 23	25.30																
23	27.19	+1.80															
24	28.71	+1.52															
25	30.56	+1.85															
26	32.55	+1.99															
27	33.95	+1.40															
28	34.87	+0.92															
29	35.40	+0.53	161,753	226,806	39.7	49.4	60.5	4,071		4.567	737,187	VI	5			Rods.	
30	35.52	+0.12															
31	35.23	—0.29															
1882. Jan. 1	34.87	—0.36												16			
2	34.49	—0.38	163,306	229,373	40.4	50.0		4,039	+2,507	3.721	607,678	XII	3	25		M.	
3	34.30	—0.19					58.1							33			
4	34.39	+0.09												33			
5	34.41	+0.02												34			
6	34.18	—0.23	161,855	229,808	40.0	50.1	57.8	3,988	+ 435	3.741	605,568			38		M.	
7	33.79	—0.39	159,517	229,652	39.3	40.1		3,948	— 156	3.704	600,464			58		M.	Below bottom of slough.
8	33.48	—0.31												55			
9	33.46	—0.02	157,858	229,366	40.4	50.0		3,912	— 286	3.495	551,661	VI	3	41		M.	
10	33.64	+0.18					57.2							43			
11	34.41	+0.77	163,229	230,989	40.9	50.4	58.4	3,995	+1,623	3.751	612,205	VIII	3	38		M.	Slough included.
12	35.53	+1.12												37			
13	36.97	+1.44	174,904	232,147	41.7	50.6		4,197	+1,158	4.519	790,401			46		M.	
14	38.57	+1.60					62.8							40			
15	39.82	+1.25												49			
16	41.23	+1.41												37			
17	42.45	+1.22												18			
18	43.63	+1.18										II	3	25			
19	44.62	+0.99	207,403	234,130	47.4	51.0	70.6	4,376	+1,983	5.225	1,083,623	XII	3	29		M.	Above top of embankment.
20	45.55	+0.93										VII	2	36			
21	46.38	+0.83	214,180	234,508	47.8	50.4		4,420	+ 378	5.757	1,233,153	VI-VII	3	37		M.	
22	47.12	+0.74												30			
23	47.70	+0.58												34			
24	48.09	+0.39												39			

OHIO RIVER. *Discharge observations at Paducah, Ky.—Continued.*

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Dimensions of cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity.	Discharge per second.	Direction and force of wind.		Temperature. Air.	Temperature. Water.	Observer.	Remarks.
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*						
Jan. 25	48.34	0.20															
26	48.56	0.22															
27	48.72	0.16															
28	48.74	0.02	[illegible], 040	[illegible]	[illegible]	[illegible]	[illegible]	4, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
29	48.72	0.02															
30	48.66	−0.06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4, [illegible]	[illegible]	[illegible]	[illegible]	VI	[illegible]	[illegible]		[illegible]	
31	48.76	0.10															
Feb. 1	48.79	0.03															
2	48.77	0.02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
3	48.71	0.06	[illegible], 110	[illegible], 410	51 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]	
4	48.48	0.23															
5	48.11	0.37															
6	47.58	0.53															
7	47.09	0.49															
8	46.50	−0.59															
9	45.82	−0.68															
10	44.96	0.86	[illegible]	[illegible]	48.1	[illegible]	[illegible]	4, [illegible]	[illegible]	[illegible]	[illegible]	VI	[illegible]	[illegible]		M.	
11	43.93	1.03															
12	43.18	−0.75															
13	43.16	−0.02															
14	42.99	−0.17	[illegible], 240	[illegible]	[illegible]	[illegible]	[illegible]	4, [illegible]	−[illegible]	[illegible]	[illegible]		1	[illegible]		M. A.	Top of embankment.
15	42.85	0.14															
16	43.43	0.58															
17	44.67	1.24															
18	45.11	+0.44															
19	45.51	+0.40															
20	45.80	+0.29															
21	46.75	+0.95															
22	47.61	+0.86	223, 104	234, 068	48.7	51.0		4, 584	+1, 732	4.847	1, 081, 848	IX	8			M.	
23	48.52	+0.91					73.1										
24	49.32	+0.80															
25	49.77	+0.45	235, 782	238, 121	51.4	51.9	74.0	4, 586	+4, 058	4.980	1, 174, 161	VII	2			M.	
26	49.95	+0.18															
27	49.84	−0.11	237, 025	238, 126	51.7	51.9		4, 587	+ 5	4.619	1, 094, 725	VII-VIII	1			M.	§ V. probably too low. Meter

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	[illegible]	[illegible]		[illegible]	[illegible]	....	[illegible]
5	47.65	—0.72	....	....	....	....	....	....	....	....	....	....		[illegible]	....	....
6	46.96	—0.60												[illegible]	....	....
7	46.29	—0.67	....	....	....	....	....	....	....	....	....	....		[illegible]	....	....
8	45.48	—0.81					71.1							[illegible]	....	
9	45.31	—0.14	221,831	239,607	50.0	52.2	70.7	4,440	+2,891	4.691	1,031,841	III	4	43	....	M.
10	45.16	—0.18	....	....	....	....	....	....	....	....	....	XII	5	53	....	....
11	45.00	—0.16	213,000	235,247	48.0	51.3	70.2	4,440	—4,360	4.190	803,481	VI	1	45	....	M.
12	45.15	+0.15	....	....	....	....	....	....	....	....	....	....		40	....	....
13	45.33	+0.18	....	....	....	....	....	....	....	....	....	I	5	46	....	....
14	45.37	+0.04	215,430	236,443	48.5	51.5	60.3	4,440	+1,106	4.475	963,060	VI	5	48	....	M.
15	45.27	—0.10	215,251	236,588	48.5	51.6	.....	4,440	+ 145	4.365	939,488	IX-X	4	64	....	M.
16	44.96	—0.31	....	....		....	60.7	....	....	....	....	....		53	....	....
17	44.44	—0.52	....	....	....	....	....	....	....	....	....	VI	6	51	....	....
18	43.68	—0.76	211,890	237,234	47.9	51.7	60.8	4,415	+ 646	4.309	910,787	VII-VIII	2-4	70	....	M.
19	42.91	—0.78	....	....	....	....	....	....	....	....	....	....		55	....	....
20	41.59	—1.32	198,307	236,036	45.7	51.5	.....	4,340	—1,198	4.243	841,659	IX	0	70	....	M.
21	39.95	—1.64	....	....	....	....	....	....	....	....	....	....		46	....	....
22	38.00	—1.95	....	....	....	....	....	....	....	....	....	....		48	....	....
23	36.27	—1.73	171,815	231,870	41.5	50.5	.....	4,137	—4,106	3.873	665,490	VIII-IX	5	50	....	M.
24	35.28	—0.99	....	....	....	....	....	....	....	....	....	....		48	....	....
25	34.87	—0.41	107,721	233,722	41.4	50.9	60.6	4,033	+1,852	4.081	684,575	VII-VIII	6	58	....	M.
26	34.85	—0.02	....	....	....	....	....	....	....	....	....	....		58	....	....
27	35.07	+0.22	....	....	....	....	....	....	....	....	....	IX	7	50	....	....
28	35.51	+0.44	168,513	232,760	41.2	50.7	60.3	4,085	— 962	4.110	692,309	III-IV	3	49	....	M.
29	36.07	+0.56	172,273	233,309	41.6	50.9	61.2	4,135	+ 549	4.084	703,475	VIII	7	65	....	M.
30	36.52	+0.45	173,846	233,064	41.9	50.8	61.5	4,149	— 245	4.041	702,388	III	3	55	....	M.
31	36.88	+0.36	....	....	....	....	....	....	....	....	....	....		57	....	....
Apr. 1	36.94	+0.06	176,398	233,794	42.3	50.9	63.6	4,170	+ 730	4.148	731,743	IX	3	69	....	M.
2	36.54	—0.40	....	....	....	....	....	....	....	....	....	....		73	....	....
3	35.75	—0.79	168,876	231,073	41.0	50.4	60.0	4,120	—2,721	4.052	684,250	IX	3	73	....	M.
4	34.30	—1.45	163,058	231,091	40.7	50.4	58.3	4,002	+ 18	3.859	629,165	IX	8	74	....	M.
5	32.05	—2.25	153,673	230,733	39.8	50.3	.....	3,860	— 358	3.685	566,358	IX	3	76	....	M.
6	29.37	—2.68	....	....	....	....	....	....	....	....	....	....		71	....	....
7	26.50	—2.87	133,615	231,833	35.5	50.5	.....	3,763	+1,100	3.118	416,670	VI	1	64	....	M.
8	25.60	—0.90	130,368	231,871	34.6	50.5	50.5	3,762	+ 38	3.316	432,330	VI	1	68	....	M.
9	26.11	+0.51	....	....	....	....	....	....	....	....	....	....		71	....	....
10	26.55	+0.44	....	....	....	....	....	....	....	....	....	....		50	....	....
11	26.60	+0.05	133,960	231,808	35.6	50.5	49.6	3,763	— 63	3.386	453,507	IV	5	39	....	M.
12	26.23	—0.37	....	....	....	....	....	....	....	....	....	....		40	....	....
13	25.64	—0.59	....	....	....	....	....	....	....	....	....	....		47	....	....
14	25.11	—0.53	128,443	231,794	34.5	50.5	49.3	3,724	— 14	3.142	403,601	III	3	46	....	M.
15	24.81	—0.30	127,109	231,592	34.1	50.5	48.8	3,722	— 202	3.051	387,817	XI	4	50	....	M.
16	24.54	—0.27	....	....	....	....	....	....	....	....	....	....		51	....	....
17	24.11	—0.43	124,407	231,401	33.5	50.4	48.5	3,719	— 191	2.822	351,089	V	3	57	....	M.
18	23.45	—0.66	121,934	231,312	32.8	50.4	.....	3,718	— 89	2.664	324,873	VI-VII	3-5	61	....	M.
19	22.75	—0.70	....	....	....	....	....	....	....	....	....	....		68	....	....
20	21.72	—1.03	114,411	230,216	31.0	50.2	45.9	3,695	—1,096	2.611	298,757	XII	3	60	....	M.
21	20.64	—1.08	....	....	....	....	....	....	....	....	....	....		67	....	....
22	19.62	—1.02	106,287	229,894	28.8	50.1	43.6	3,693	— 322	2.405	265,133	VII	3	67	....	M.
23	18.68	—0.94	....	....	....	....	....	....	....	....	....	....		54	....	....

Below top of embankment.

OHIO RIVER.—*Discharge observations at Paducah, Ky.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1882.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cubic feet.			°	°		
Apr. 24	17.79	−0.89	99,507	229,870	26.6	50.1	41.4	3,690	− 24	2.247	223,624	VI	3	54		M.	
25	17.44	−0.35	98,060	229,876	26.6	50.1		3,690	+ 6	2.215	217,180	VI	3	66		M.	
26	17.79	+0.35												68			
27	18.35	+0.56	101,106	229,752	27.4	50.1	42.1	3,690	− 124	2.255	227,989	II–III	6	63		M.	
28	18.90	+0.55	103,303	229,742	28.0	50.1	42.7	3,690	− 10	2.329	240,600	Calm		61		M.	
29	19.40	+0.50												57			
30	19.73	+0.33												56			
May 1	19.90	+0.17	107,625	230,397	29.1	50.2	44.0	3,696	+ 655	2.365	254,516	VI	3	59		M.	
2	20.07	+0.17												60			
3	20.22	+0.15	108,663	230,252	29.4	50.2		3,696	− 145	2.474	268,779	VI	3–5	64		M.	
4	20.38	+0.16												73			
5	20.30	−0.08	109,383	229,950	29.6	50.1		3,696	− 302	2.480	271,322	VII–VIII	7	76		M.	
6	19.94	−0.36	108,275	229,943	29.3	50.1	44.0	3,696	− 7	2.487	269,261	IX	3	71		M.	
7	19.44	−0.50												71			
8	19.24	−0.20	105,257	229,814	28.5	50.1		3,694	− 129	2.533	266,668	VII	5	74		M.	
9	21.78	+2.54												65			
10	25.50	+3.72	130,344	231,872	34.6	50.5		3,766	+2,058	3.357	437,513	X	6	70		M.	
11	28.71	+3.21	142,806	232,170	37.9	50.6	53.4	3,768	+ 298	3.647	520,823	IX–X	3	63		M.	
12	31.51	+2.80												50			
13	32.96	+1.45												45			
14	33.18	+0.22												54			
15	32.98	−0.20	159,003	231,687	41.0	50.5		3,880	− 483	3.703	588,863	XII	6	55		M.	
16	32.82	−0.16	157,918	231,316	40.7	50.4	56.5	3,880	− 371	3.686	582,070	XII	1	55		M.	
17	32.93	+0.11	158,036	231,034	40.7	50.4		3,880	− 282	3.738	590,706	II–III	2	60		M.	
18	33.23	+0.30	159,297	231,156	40.9	50.4	57.0	3,892	+ 122	3.760	598,911	VI	1	65		M.	
19	33.51	+0.28												68			
20	33.77	+0.26	161,348	231,036	41.2	50.4	59.0	3,916	− 120	3.810	614,795	VIII	2–4	69		M.	
21	34.24	+0.47												54			

									+ 312	3.465	510,963	XI	3-5	80	....	
6	31.26	+0.27	148,341	227,677	38.9	49.6	53.6	3,814	— 147	3.490	517,990	Calm		65	....	M.
7	31.35	+0.07	148,720	227,747	39.0	49.7	53.1	3,814	+ 70	{ 3.444 { 3.498	512,153 519,426	{ IX	3	69 70	....	M. { M. { R.
8	31.10	—0.25	148,102	227,958	38.8	49.7	52.0	3,815	+ 206	3.447	510,470	IX	1	74	....	M.
9	30.70	—0.40	145,854	227,205	38.4	49.5	51.8	3,800	— 748	3.359	489,968	VII	1	78	....	M.
10	30.03	—0.67	143,821	227,140	37.9	49.5	50.6	3,783	— 65	3.188	456,843	VIII	1	80	....	M.
11	29.00	—1.03	....	....	....	....	....	....	....	....	....	....		80	....	....
12	27.80	—1.11	134,945	227,180	35.9	49.5	49.1	3,758	+ 40	3.003	405,211	XI	3	74	....	M.
13	26.18	—1.76	127,625	226,445	34.2	49.4	46.0	3,729	— 735	{ 2.828 { 2.899	300,800 369,926	} VIII }	4	79	....	{ M. { R.
14	24.11	—2.02	120,625	226,681	32.4	49.4	45.1	3,719	+ 236	2.622	316,300	VIII-IX	5	83	....	M.
15	22.30	—1.81	113,554	226,318	30.5	49.8	42.6	3,718	— 363	2.560	290,673	IX	3-4	80	....	M.
16	21.08	—1.22	....	....	....	....	....	....	....	....	....	....		75	....	....
17	20.87	—0.71	105,838	226,842	28.5	49.3	40.9	3,710	+ 24	2.418	255,905	VI-VII	5	75	....	M.
18	21.22	+0.85	....	....	....	....	....	....	....	....	....	....		75	....	....
19	23.30	+2.08	....	....	....	....	....	....	....	....	....	....		68	....	....
20	25.20	+1.90	125,262	227,404	33.6	49.6	46.1	3,730	+1,063	3.365	421,563	VI	3	69	....	M.
21	25.72	+0.52	....	....	....	....	....	....	....	....	....	....		80	....	M.
22	26.14	+0.42	128,010	226,703	34.3	49.4	46.7	3,736	— 701	{ 3.304 { 3.292	430,030 421,243	} V }	1	82	....	{ M. { R.
23	26.36	+0.22	129,060	226,924	34.5	49.5	46.6	3,736	+ 221	3.336	430,565	XI	1	83	....	M.
24	26.47	+0.11	129,467	226,898	34.7	49.5	46.8	3,736	— 26	3.267	423,008	IX	3	87	....	M.
25	26.23	—0.24	....	....	....	....	....	....	....	....	....	....		88	....	....
26	25.73	—0.50	126,834	227,017	34.0	49.5	46.3	3,733	+ 140	2.973	377,085	IX	5	80	....	M.
27	24.95	—0.78	124,136	227,119	33.3	49.5	45.1	3,724	+ 72	2.859	354,876	X	1	81	....	M.
28	23.87	—1.08	119,979	227,118	32.2	49.5	44.3	3,724	— 1	{ 2.708 { 2.568	332,107 308,979	} X }	5	83	....	{ M. { R.
29	22.85	—1.02	....	....	....	....	....	....	....	....	....	....		82	....	....
30	21.95	—0.90	113,480	227,561	30.5	49.6	42.2	3,724	+ 443	2.460	279,200	X	7	82	....	M.
July 1	22.25	+0.30	114,678	227,824	30.8	49.7	42.7	3,724	+ 263	2.531	290,239	IX-X	6	82	....	M.
2	22.16	—0.09	....	....	....	....	....	....	....	....	....	....		79	....	....
3	22.23	+0.07	113,527	226,863	30.5	49.5	42.6	3,724	— 961	2.326	264,121	VIII	3	72	....	M.
4	22.90	+0.67	....	....	....	....	....	....	....	....	....	....		67	....	....
5	23.47	+0.57	118,495	227,349	31.8	49.6	43.9	3,728	+ 486	2.364	280,169	I	6	67	....	M.
6	24.27	+0.80	121,357	226,973	32.5	49.5	44.7	3,732	— 376	{ 2.369 { 2.300	287,549 279,105	} V }	3	70	....	{ M. { R.
7	24.87	+0.60	....	....	....	....	....	....	....	....	....	....		69	....	....
8	25.25	+0.38	124,790	226,795	33.4	49.4	45.7	3,736	— 178	2.405	311,323	VIII-IX	4-5	73	....	M.
9	25.25	0	....	....	....	....	....	....	....	....	....	....		78	....	....
10	24.88	—0.37	123,109	226,358	33.0	49.3	45.2	3,736	— 437	2.314	284,910	VIII	4-5	79	....	M.
11	24.47	—0.41	121,097	226,060	32.4	49.3	44.8	3,736	— 398	2.367	286,600	IV	2	79	....	M.
12	23.80	—0.67	....	....	....	....	....	....	....	....	....	....		81	....	....
13	22.78	—1.02	....	....	....	....	....	....	....	....	....	....		72	....	....
14	21.68	—1.10	110,817	226,091	29.7	49.3	41.3	3,736	+ 31	2.205	254,337	Var.	3	69	....	M.
15	20.83	—0.85	108,322	226,713	29.1	49.4	41.0	3,720	+ 622	{ 2.369 { 2.347	256,626 254,212	} VI-VII	3	72	....	{ M. { R.

[illegible] — Continued.

No.								Gauge	Area	Mean velocity per second	Discharge per second	Direction and force of wind		Temperature Fahr. Air	Temperature Fahr. Water	Method	Remarks
								Feet	Sq. feet	Feet	Cubic feet			°	°		
														77			
								[illegible]	— [illegible]	2.492	256,563	VI-VII	1	75	....	M.	
														78			
								[illegible]	— 561	2.356 2.254	228,193 215,560	III	3	75	....	M. R.	
								[illegible]	+ 52	2.304	214,288	VI	1	74	....	M.	
								[illegible]	+ 4[illegible]6	2.295	208,664	X	1	70	....	M.	
							[illegible]	3,694	— 529	2.247	190,430	VI	3	72	....	M.	
														75			
						[illegible]	[illegible]	3,686	— 206	2.069	172,977	VI	1	75	....	M.	
						49.1	33.1	3,683	— 176	1.973 1.877	156,536 148,957	VI	2	78	....	M. R.	
														78			
					[illegible]	49.2	31.1	3,662	+ 472	1.877	133,874	V	1	70	....	M.	
					[illegible]	49.2	30.1	3,656	+ 215	1.862	127,331	VIII	3	70	....	M.	
					18.0	49.2	29.8	3,654	— 299	1.805	124,834	V-VI	3	70	....	M.	
														79	....	M.	
		[illegible]	[illegible]	[illegible]	17.0	49.1	27.7	3,644	— 358	1.878	116,410	IX	3-4	80	....	M.	
		[illegible]	[illegible]	[illegible]	16.7	49.1	28.2	3,643	+ 161	1.834	111,584	VII	3	81	....	M.	
		[illegible]	60,[illegible]	22[illegible],994	16.7	49.2	27.1	3,642	+ 562	1.887 1.777	114,855 108,165	IX	5	70	....	M. R.	
		[illegible]	60,769	225,508	16.5	49.2	27.7	3,642	— 306	1.898	114,388	XI	3	77	....	M.	
	[illegible]	[illegible]	60,0[illegible]	225,341	16.5	49.1	28.0	3,640	— 257	1.970	118,916	III	1	75	....	M.	
	[illegible]	[illegible]	6[illegible],629	225,365	17.2	49.1	27.6	3,643	+ 24	2.161	135,371	VI	4	74	....	M.	
6	[illegible]	[illegible]												79			
7	[illegible]	[illegible]	75,913	225,141	20.1	49.1	30.7	3,668	— 224	2.553	188,668	IX-X	3	76	....	M.	
8	[illegible]	[illegible]	75,701	225,156	20.6	49.1	32.2	3,672	+ 15	2.627	198,889	XII	7	77	....	M.	
9	[illegible]	[illegible]	75,940	225,230	20.7	49.1	32.2	3,672	+ 74	2.505	190,203	XI	4-5	70	....	M.	
10	[illegible]	[illegible]	75,511	225,319	20.6	49.1	32.1	3,672	+ 89	2.514 2.415	189,943 182,438	I-II	3	67	....	M. R.	
11	[illegible]	[illegible]	75,531	225,126	20.6	49.1	32.2	3,674	— 103	2.544	192,170	Calm		68	....	M.	
12	[illegible]	[illegible]	75,852	225,223	20.7	49.1	32.2	3,674	+ 97	2.557	193,980	IV-V	3	69	....	M.	

	17	[illegible]	—0.[illegible]	71,[illegible]	[illegible]	[illegible]	49.[illegible]	......	3,[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	18	11.84	—0.67													72	M.
	19	11.13	—0.11	70,[illegible]	[illegible]	16.5	48.1	30.8	3,667	—	[illegible]	2.[illegible]	17[illegible]	IV	5	73	
	20	10.89	—0.24													72	M.
	21	10.43	—0.46	68,882	225,021	16.8	49.1	30.1	3,660	—	365	2.430	167,581	V-VI	8	78	M.
	22	9.83	—0.60	66,438	224,429	18.2	48.9	29.3	3,658	—	502	2.[illegible]	154,697			80	M.
	23	9.18	—0.70	63,611	224,197	17.4	48.9	......	3,652	—	222	2.248 2.231	142,681 141,903	VI	3-4	78	M. R.
	24	8.44	—0.60	61,495	224,489	16.9	48.9	27.0	3,646	+	292	2.170	133,434	IX	5	74	M.
	25	7.88	—0.56	59,184	224,655	16.8	49.0	......	3,630	+	166	2.106	124,618	VII	3	75	M.
	26	7.37	—0.51	57,655	224,980	15.9	49.0	26.9	3,632	+	325	2.015	116,157	XI-XII	4	75	M.
	27	7.00	—0.37														
	28	6.79	—0.21	56,008	225,846	15.7	49.1	26.4	3,626	+	366	1.954	109,599	I-II	4	71	M.
	29	6.57	—0.22	54,958	225,085	15.2	49.1	......	3,624	—	311	1.898	104,327	III	3	73	M.
	30	6.72	+0.15	55,408	224,729	15.3	49.0	26.4	3,625	—	306	1.952 1.917	108,109 106,190	VI	1	78	M. R.
	31	6.98	+0.26	56,145	224,777	15.5	49.0	......	3,628	+	48	2.026	113,753	XII	3-4	74	M.
Sept.	1	7.15	+0.17	56,818	224,688	15.7	49.0	26.9	3,630	—	89	2.055	116,776	VI	3	73	M.
	2	7.42	+0.27													67	
	3	7.67	+0.25													70	
	4	7.86	+0.19	59,020	224,340	16.2	48.9	27.4	3,638	—	342	2.123	125,319	II	3	72	M.
	5	7.98	+0.12	59,272	224,234	16.8	48.9	......	3,640	—	112	2.158	127,925	II-III	3	69	M.
	6	8.38	+0.40	61,027	224,204	16.7	48.9	28.0	3,646	—	30	2.226	135,818	III	3	71	M.
	7	8.90	+0.52	62,557	224,093	17.1	48.9	......	3,648	—	111	2.322	145,262	IX-X	5	69	M.
	8	9.25	+0.35	63,735	223,958	17.5	48.8	28.9	3,648	—	135	2.352	149,905	Var.	1	72	M.
	9	9.30	+0.05	63,845	223,959	17.5	48.8	......	3,648	+	1	2.354	150,293	III-IV	5	71	M.
	10	9.01	—0.29													68	
	11	8.64	—0.37													65	
	12	8.14	—0.50	59,805	224,401	16.4	48.9	27.4	3,639	+	442	2.155	128,888	VI	5	65	M.
	13	7.69	—0.45	58,640	224,618	16.1	49.0	......	3,635	+	217	2.181 2.044	124,969 119,807	IX	6	74	M. R.
	14	7.37	—0.32	57,487	224,809	15.8	49.0	26.9	3,632	+	191	2.002	115,087	IX	3	76	M.
	15	7.08	—0.29	57,105	225,298	15.7	49.1	26.2	3,629	+	489	2.011	114,810	IX	1	77	M.
	16	7.44	+0.36	58,206	225,310	16.0	49.1	......	3,633	+	12	2.084 2.067	121,297 120,284	VI	1	80	M. R.
	17	9.23	+1.79													74	
	18	10.69	+1.46	69,093	225,133	19.0	49.1	......	3,661	—	177	2.615	182,228	IX	6	77	M.
	19	11.93	+1.24	74,513	225,041	20.3	49.1	31.6	3,670	—	92	2.780	207,136	IX	5	75	M.
	20	12.65	+0.72	76,010	224,831	20.9	49.0	......	3,676	—	210	2.870	220,751	XII	2	67	M.
	21	12.27	—0.38											XII-I	6	55	
	22	11.23	—1.04	72,073	224,913	19.7	49.0	30.3	3,666	+	82	2.541	183,124	I	4	56	M.
	23	10.15	—1.08	67,906	224,828	18.6	49.0	......	3,658	—	85	2.388 2.406	162,364 163,399	I	2	60	M. R.
	24	9.38	—0.77													61	
	25	8.70	—0.68	60,932	224,959	16.7	49.0	......	3,647	+	131	2.211	134,835	III	4	60	M.
	26	7.86	—0.84	59,544	224,809	16.4	49.0	26.3	3,631	—	150	2.091	124,628	III	5	59	M.
	27	7.15	—0.71													59	
	28	6.52	—0.63	54,772	225,009	15.1	49.1	......	3,624	+	200	1.926 1.905	105,487 104,355	VI	6	65	M. R.
	29	6.13	—0.39	53,405	225,163	14.8	49.1	25.3	3,619	+	154	1.887	100,764	IX	5	69	M.
	30	5.82	—0.31	52,427	225,126	14.5	49.1	......	3,616	—	37	1.850	96,969	VII	1	70	M.

3	3.06	—0.11	41,848	224,263	11.6	48.9	......	3,594	— 50	1.293	52,940	III	1	56	....	M.
4	2.99	—0.05	41,240	224,249	11.5	48.9	22.9	3,600	— 16	1.324	54,622	V-VI	3-4	55	....	M.
5	2.94	—0.04	....	....	......	......	......	....	....	....	....	....		57	....	......
6	3.00	+0.06	41,868	224,240	11.5	48.9	......	3,593	— 9	1.381	57,044	VIII-IX	5	58	....	M.
7	3.15	+0.15	41,815	224,208	11.6	48.9	22.3	3,594	— 32	1.356	56,685	VI	1	54	....	M.
8	3.30	+0.15	42,434	224,324	11.8	48.9	......	3,596	+ 116	1.436	60,937	VI-VII	3	59	....	M.
9	3.52	+0.22	43,159	224,294	12.0	48.9	......	3,598	— 30	1.449	62,541	IX	3-5	62	....	M.
10	4.11	+0.59	45,116	224,306	12.5	48.9	......	3,604	+ 12	1.532	69,130	VIII	5	67	....	M.
11	4.35	+0.24	46,293	224,401	12.8	48.9	23.9	3,608	+ 95	1.657	76,728	VII-VIII	6	65	....	M.
12	4.62	+0.27	....	....	......	......	......	....	....	....	....	....		49	....	......
13	5.10	+0.48	....	....	......	......	......	....	....	....	....	....		33	....	......
14	4.90	—0.20	48,078	224,164	13.3	48.9	......	3,613	— 237	1.718	82,588	VIII	6	40	....	M.
15	4.77	—0.13	47,307	224,061	13.1	48.8	23.9	3,615	— 103	1.714	81,259	I	1	44	....	M.
16	4.73	—0.04	47,554	224,326	13.2	48.9	......	3,616	+ 265	{1.674 {1.701	79,595 80,013	}VIII-IX,	3-5	47	....	{M. {R.
17	4.91	+0.18	....	....	......	......	......	....	....	....	....	....		44	....	......
18	5.15	+0.24	....	....	......	......	......	....	....	....	....	....		41	....	......
19	5.14	—0.01	....	....	......	......	......	....	....	....	....	....		40	....	......
20	5.03	—0.11	48,945	224,523	13.5	48.9	......	3,620	+ 197	1.761	86,177	II-III	5	38	....	M.
21	4.87	—0.16	48,445	224,602	13.4	49.0	23.5	3,618	+ 79	1.770	85,761	XI	4-6	38	....	M.
22	4.70	—0.17	47,759	224,603	13.2	49.0	......	3,615	+ 1	1.681	80,296	VI	1	42	....	M.
23	4.64	—0.06	....	....	......	......	......	....	....	....	....	....		41	....	......
24	4.57	—0.07	47,153	224,502	13.1	48.9	23.3	3,601	— 101	1.657	78,137	XII	4	33	....	M.
25	4.47	—0.10	46,833	224,506	13.0	48.9	......	3,600	+ 4	1.654	77,445	VI	3	37	....	M.
26	4.54	+0.07	....	....	......	......	......	....	....	....	....	....		42	....	......

[illegible]—AT COLUMBUS, KY., J. H. DAVIS, ASSISTANT IN CHARGE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 7, 1883.

SIR: I have the honor to submit the following report on the observations made at [illegible] from December 17, 1881, to November 25, 1882. The work consisted of:

[illegible]

[illegible] vertical velocity curves.

[illegible] transverse velocity curves.

[illegible] soundings.

[illegible] soundings.

[illegible] surface currents.

[illegible]—The party, consisting, at first of assistant, recorder, and three [illegible] on the 29th of November. After locating, operations [illegible] a reconnaissance of the river in front of town for the purpose [illegible] gauging section. This being completed, several days were [illegible] necessary preparations for the work in view. These were [illegible] account of having shipped most of the material to Natchez, the [illegible] for the observations. It was not returned to Columbus till [illegible] days after the arrival of the party. Meanwhile the party were [illegible] catamaran and making such utensils as were needed in manip[illegible]. Range lines were also laid off, and signals made and erected upon [illegible] was put up, and tri-daily observations upon the stage of the [illegible]. The preliminaries having been completed, the first discharge [illegible] on the 17th of December.

[illegible] discharge observations were made daily, Sundays excepted. From [illegible] 1881, to November 25, 1882, there were made in all 243 sets of discharge [illegible] sets were made with double floats, 83 sets with rod-floats, [illegible] the current meter. Frequent omissions occurred in the early part [illegible] of bad weather and accidents to instruments and machinery. [illegible] observations for a vertical curve were made upon each day that the [illegible] discharge measurements. There were frequent omissions, how[illegible] lack of time. During the year there were 101 curves determined. [illegible] across the river so as to include all depths and velocities.

[illegible] observations were made monthly. Owing to high water [illegible] to the launch, they were not begun till the last of March. [illegible] close of the work [illegible] curves were determined. They extend [illegible] all the stages of the river from high to low.

[illegible] weekly when the time was not fully occu[illegible]. There were 31 sets made during the year, a set con[illegible] reach of 500 feet.

[illegible] purpose of determining the amount [illegible] changes in the stage of the river. They [illegible] of about 3 feet on the gauge. From [illegible] were made.

[illegible] currents were unsuccessful. The [illegible] which it was designed. The results

[illegible] into three classes: 1st, observations [illegible] made with rod-floats; 3d, observations [illegible] each of a subdivision, as will be

[illegible] floats were used in discharge meas[illegible] at the time. They were of the [illegible] W. H. [illegible], at Fulton, Tenn., a small cord [illegible] parts.

[illegible] rods were substituted for double [illegible] diameter, connected and buoyed by a [illegible] were perforated so as to admit the [illegible] increased about 37 feet in deep water. [illegible] river depth on the gauging section. [illegible] March 18, and at intervals of about [illegible] observations. In all observations previous to [illegible] paths only, and by means of the [illegible]. After [illegible] they were located in two points, by [illegible]. On the 18th of September, a goniometer was substituted for the

[illegible]

[illegible] instructions were to use the current meter in discharge measurements, but it [illegible] impracticable to do so in the early part of the work. It could not be used [illegible] the launch, which did not arrive till the 26th of December, and was not serv-

ticable for more than a month following, except for very short periods. The meter was first used on January 24, but with only partial success. It was also used on the 27th and 28th, and a few times in February. From the middle of February to the middle of March, the high water and heavy drift rendered it very difficult to get a complete discharge measurement with the meter at all, and at best the work was very unsatisfactory. During a week of the time, also, the launch was at Cairo for repairs.

It being very desirable to have a complete set of observations over this the highest stage of the river, not only of that year, but then on record, it was thought advisable to use rod-floats exclusively, that being a surer method of obtaining complete results. After March 18, the meter came into constant use, the water having fallen sufficiently to handle it with safety and comparative ease. The rod-floats were still used at intervals of about two weeks, in accordance with instructions, and sometimes oftener, when the meter needed repairing After and including March 18, with few exceptions, the boat was anchored during the observations with the meter. Previous to that time, the observations were made without anchoring. Both methods are described below.

METHODS.

Double floats.—Two ranges were laid off, 100 feet apart, and as nearly parallel as was practicable, with no better instrument than a cloth tape-line. They were also practically at right angles to the thread of the current.

On these ranges front and back signals were erected on both shores, and also intermediate ones for use in measuring distances with the telemeter. The floats were manipulated by an observer in a skiff. The connecting cord was made of sufficient length to allow the subfloat to run practically at mid-depth, the limit being between four-tenths and six-tenths of the depth. The float was put out far enough above the upper range to assume a uniform rate before reaching it. The skiff was kept in line with the float and at a convenient distance behind it, while passing the ranges. The distance from shore was measured by the observer in the skiff, when he reached a point about midway between the two ranges, the telemeter being used for this purpose. Soundings were taken on each range by a leadsman in the bow of the skiff. After passing the lower range, the float was picked up, the skiff rowed above line, and the operation repeated for each successive observation. The float was timed by an observer on shore, who watched its crossing of the ranges, and at the same time manipulated a stop-watch. To aid him in determining when the float crossed the ranges, a fine vertical wire was employed at each of the range stations. By standing just behind it, and keeping it in line with himself and the signal across the river, the time of the floats crossing could be determined with tolerable exactness. A field-glass was also used, through which the wire, the signal across the river, and the float, could be distinctly seen at the same time.

The actual float-path could not be measured by this method. In the computations it was considered 100 feet. In most cases it was greater, and where great accuracy is desired, the length of path should be corrected by those determined afterwards at corresponding stages, by use of the transit.

Rod-floats.—(1). Previous to the use of the transit, March 1, the method of using rod-floats was the same as that for double floats, except that they were not run at mid-depth. With few exceptions 37 feet was the immersion used in deep-water observations. That for shallow water was regulated by the sounding, the float being run as near the bottom as practicable without touching.

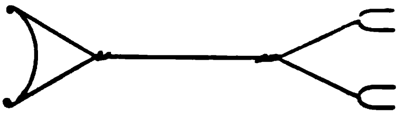
Rod-floats.—(2). A B. & B. transit (No. 237) was received the latter part of February, and brought into immediate use in the discharge observations with floats. The range lines were tested and found but slightly out. A base line of 515 feet was laid off at right angles to the ranges, and a transit station established at its extremity. A telegraph line was erected for the purpose of signalling from the station on the ranges to the transit station. A key was placed in the circuit at each of the range stations and a sounder at the transit station. The circuit was left open and could be closed by touching either key. The floats were handled from a skiff, the launch being used for towing it above the ranges. The boatmen were necessarily relied upon for correct manipulation of the float as well as the taking and recording of the soundings. The transit being in position and properly set with the lower plate clamped, the battery and all being in perfect working order, the following programme was carried out for each observation:

The float was spliced and lowered some distance above the upper range, so as to assume an erect position and uniform movement before reaching it. An observer on the upper range watched the float until it came within a few feet of line, when he touched his key twice, for a ready signal to the observer at the transit. When the float reached the range the observer touched his key once and immediately went to the lower range. Here the same signals was given as on the upper range.

The observer at the transit having brought the float into his field of view, followed

... same ... upp
... following the
... immediate ... of
... changing ... again ca
... it ... the low
same ...
... transi
... signals ... reac
To ... of
... means ... ma
with ... observa
river.

... men ashore.—The ... a
... anchor. The ... a
... aid of the ...
... was of ...
... manner: The ...
... allowing a ... was
... kevels of the catamaran. The ... of th
... of variable length forming a ...



... consisting of the launch and catamaran together with th
... with the current. The distance between the launch
... to suit the requirements of the ... and the depth and
... is necessary, with a strong up-stream or cross-stream wi
... the catamaran in close proximity to the launch. The
... was about 75 feet.

... lowered from the back part of the catamaran. To do th
... let into a leaden weight of 60 pounds, cylindrical
... the rod was a movable ring for attaching the lowering
... to the rod and weight, was suspended by a No. 11
... over a pulley at the back of the catamaran, and thenc
... to overcome, as much as possible, the action of
... down stream, a ... was at
... over a pulley at the stern ...
... catamaran. The meter was lowered or raised by t
... of the two reels. The relative rates of w
... the meter down vertically ...
... for this relation varied with the
... and also with the velocity of the
... increased with experience, the ...
... his cord. With the grea
... vertical in high stages of the
... down and up integrations. How
... practically no error resulting from th

... measuring discharges with th
... was run some distance a
... approximately by means
... the anchor was cast
... When sufficiently ne
... level, and ...
... the discharge ...
... was ...

rate, not exceeding one-half feet per second, the man at turns. At the instant of giving signal the observer noted the electrical register, by turning on the switch.

a point within a few turns of the bottom, the man at the and upon feeling the weight touch, he called "time" and his reel. When the time signal was called, the observer noted read the register without stopping it.

the time and the register reading correctly required some skill, espe- high water. It can be done by the observer keeping in mind the read- dial only, from the sound of the register, counting the ticks, one, half, &c.

me is called, the seconds of the watch time, and the reading of the last dial gister, can be jotted down hastily, while the hour and minutes of the time readings of the remaining dials of the register can be obtained at leisure. ttle practice the nearest second of time and the nearest half revolution of wheel can be accurately obtained by the same observer. The meter was to the surface at the same rate as that of the descent, the man at the reel time" when the starting point was reached. The observer again read the d stopped the register, recording the readings of both.

esults of integration were satisfactory. The meter was now lowered for mid- ervations. This was done by giving the main reel one-half the number of uired to send the meter to the bottom. The meter was run at mid-depth for ve minutes, the register being read at the end of each minute. When it ble to hold the boats in one position the meter was run a whole number of at mid-depth; otherwise it was run as described in the method without g.

are was exercised by the engineer and steersman to hold the boats in one uring the observation, using the engine when necessary to assist the anchor. n not needed the engine was kept moving slowly, except in extreme low order to prevent the wheel of the launch from retarding the current near e. In extreme low water the engine could not be run without changing on of the boat.

rent meter.—(2.) Without anchoring.—Only mid-depth observations were this way, and at times when anchoring was not practicable. The method slightly from that given above. After drifting into position, the sounding en taken, the launch was held as nearly in one position as was possible by l watchfulness of the steersman and engineer. The meter being lowered to , as estimated from the sounding, the catamaran was brought to the gang- n, when the time was noted and the register started. The engineer, stand- is hand on the throttle-valve, was able to keep the boat almost on the same ing the observation. If, however, at the end of five minutes, the catamaran a little above or below the gauging section it was brought into position. time was again noted and the register stopped. The readings of the latter n and recorded at the end of each minute, and also at the close of the ob-

t of starting and stopping the meter register on the same range practically the effects of any movement up and down stream during the observation. s due to lateral movement are not so easily compensated, as the rate of the ccelerated by a movement in either direction. Such errors were compara- all, however, except in cases of very high wind, when the boat was liable to osition to a considerable extent in a lateral direction.

discharge observations with the meter, consisted of velocities at mid-depth tegration, when anchored, and at mid-depth when not anchored, at from 12 ions across the river on the gauging section. A sounding was taken at each s the bottom was very even, this was thought sufficient to give a correct e section.

METERS AND METER-RATING.

is meter was employed exclusively. During the year Nos. 3, 6, and 23 were fferent periods. At times the meter in use was not in the best of order, the exceeding delicacy of the instrument and the want of a person capable ng it. The errors that might arise from this source were reduced as much as y frequent ratings. The same meter was seldom used longer than two weeks eceiving a thorough rating, and when thought advisable it was sent to Saint repairs. With the greatest precaution it was impossible to keep the meter order at all times, and consequently the frictional quantity will be found ge in some of the equations.

of rating the meter.—The rating was made in the still water of a pond about p. The meter was attached to an iron rod secured in a vertical position at

...mersed to a depth of about ... feet. The skiff, with the ... drawn through the water at a uniform velocity by a man ... steps, holding a rope attached to the bow. The time ... were taken over a distance of 150 feet in most of the ... consisted of from twelve to twenty such observations, the ... three-quarters of a foot ... feet per second.

... was as follows: When practicable, two ranges were ... the skiff and the proper distance apart. On ... stationed, who called "time" when the meter rod passed ... were taken by the observer in the skiff ... In many of the ratings this method was not prac- ... were given ... drawing the skiff, "time" being called as they ...

... as the former, as great care was taken to ... given.

... the results of rating by the method of least ...

... for the vertical velocity curves were ... with that work. ... at a station, when it was desired to ... and an observation of ... a distance corresponding to some ... minute's observation made ... was reached as near the bottom as ... in the curves were usually taken ... feet by taking such a part of ... points was of the whole number of ... observations were made at different ... there is a com- ... all depths and velocities. ... observations were made on a range ... was above the large eddy on ... at high stages of the river. ... of the launch, not at ... was as follows:

... as previously described, was sus- ... that projected about ... around a reel on ... The launch, with ... the ... sur- ... who ... was ... engine ... about three ... practicable ... and ... recorded. ... his angles ... the end of ... September

... as above ... Soundings ... the shore

... reach of 500 ... observations ... skiff in the fol-

... of the reach, ... for the line to ... the flag- ... and lower- ... the river. ... lead-line ... "back." ... sound- ... noted the time

The skiff was located by a transitman on shore, at 4 points in its path: on the upper and lower ranges, and on two ranges 200 and 300 feet respectively from the upper range. By means of back and front signals on each of the ranges, the flagman signaled to the observer at the transit when the skiff was on line. The angle was taken on the flagman, who sat near the leadsman. From 50 to 150 soundings were taken on each line of 500 feet; sometimes the number was even greater in very low water. Previous to receiving the transit, March 1, the boat was located in only one point of its path, midway between the second and third ranges, by means of the telemeter. After and including September 8 the angles were taken with a goniometer, from the station previously occupied by the transit.

Cross-section soundings.—Frequent soundings were made of a section, located in Smith's Bend, 12 miles below Columbus, for the purpose of determining the amount of scour or fill in sharp bends, corresponding to certain changes in the gauge. The soundings were all taken while drifting, either from the launch or a skiff. From 50 to 75 soundings were made at a time, distributed at equal intervals across the river. They were located by a transitman on shore, stationed at the end of a 600-foot base. The angles were taken on a flagman, stationed near the leadsman. There was also a flagman on shore to give range. After the transit was taken away in August, the goniometer was used for taking the angles. It was stationed on a new base line of 300 feet in length. In order to ascertain the character of the fill, specimens of the bottom were taken at each sounding by means of a soaped lead.

INSTRUMENTS CONSTRUCTED.

Telemeter.—Previous to March 1 no transit, sextant, or level had been furnished the party. It was therefore necessary to contrive some means by which observation stations could be located. This necessity gave rise to the construction and use of what has been denominated the telemeter. It consisted of a wooden box, having two of its faces parallel trapezoids, two of them inclined rectangles, the remaining two, the ends, being parallel rectangles. The inside dimensions were about as follows: length, 2 feet; cross-section at the smaller end, 2 by 3 inches; cross-section at the larger end, 2 by 10 inches. At the smaller end of the box was an eye-piece, which consisted of a cylindrical block of wood with a small aperture or peep-hole.

In the larger end was a longitudinal opening the full width of the box and about an inch in width. It occupied the middle line of the end of the box, and through it distant objects could be seen by looking through the eye-piece. Inside the box was a sliding reticule that contained a pair of fine parallel wires. It was arranged to slide along the central line of the inclosed space and from one end to the other. On top of the reticule was an upright post that moved in an opening in the upper face of the box, and terminated in a rectangular block of wood that moved along on top of the box. This was used as a vernier piece. The top of the box was graduated so that by means of the vernier the instrument could be read to single feet. The graduation was made in the following manner: Two signals were erected at a distance of 50 feet apart. The distance was arbitrarily chosen as the most convenient. From the middle point of the line joining the signals a perpendicular was laid off. On this two points were located, one 400 feet and the other 1,200 feet distant. At each of the points there was made a series of observations to determine the exact location of the 400 and 1,200 foot marks of the graduation on top of the box. In each of these observations the box was held so that the signals could be seen when looking through the peep-hole with the eye conveniently near it. The reticule was then moved, if necessary, by taking hold of the vernier piece on top, until the wires were brought, respectively, in line with the signals. The position of the zero of the vernier was then marked on the box.

The mean of all the observations made in this way was taken as the mark of graduation sought. Having found the 400 and the 1,200-foot marks, the remaining hundred-foot marks were obtained by dividing the space into 8 equal parts. Each of these spaces was subdivided into 10 equal parts for the 10-foot marks.

The graduation for distances less than 400 feet, and greater than 1,200 feet, was made by actual measurement with a scale, the spaces being proportional to the distances. In order to use the telemeter in measuring distances on the river, signals were put up on both shores, at a distance of 50 feet apart. Back signals were erected so that the observer could tell when he was midway between the ranges, that being necessary to perfect accuracy. A slight deviation either way made no appreciable error in long distances. To measure a distance, the observer brought the box to a horizontal position, the wires then being vertical. Placing his eye at the peep-hole, he swung the box, if necessary, until the signals came into the field of view. He then moved the sliding vernier on top of the box, until the wires were brought in line respectively with the signals. Being careful not to move the vernier, he lowered the box sufficiently to read the distance. The instrument was not capable of measuring distances greater than about 1,000 feet with accuracy. For this reason, signals were placed on both shores and measurements made each way. The accuracy with which distances could be measured with the telemeter, depended upon the stability

of the observer's position, and the consequent nicety with which the wires could b brought into line with the signals. In windy weather this was somewhat difficult but great skill was acquired by practice, and a very close approximation could b obtained at all times. Much greater accuracy could be obtained on land, when a stabl rest could be had, and it was possible to measure distances accurately to within 3 feet

Goniometer.—This was a plane table with a revolving alidade, and was arranged fo centering by means of a plumb-bob attached beneath the point of revolution. Thi point was taken as the center of an arc described on the table with a radius of 2 inches. Angles were taken with the goniometer by measuring the chords of the in cluded arcs. The angle corresponding to a measured chord was taken from Gillespie' tables. Any point in the arc could be taken for the zero point, and the chords meas ured from it. This was a matter of great convenience in setting up the instrument To measure an angle on a moving object, the eye was brought to the peep-sight an the alidade revolved so as to keep the vertical wire in line with the object. Whe the signal was given, the motion was stopped, and the intersection of the line of sigh with the arc marked with a well sharpened pencil. The chord was then measure with a triangular scale. If the chord was too long for the scale, the included arc wa divided into two or more parts, and the sum of the corresponding angles taken. Th prevented the use of a ruler being necessary. Under favorable conditions a tolerabl close degree of approximation could be attained with the goniometer.

Remarks.—On the 11th of October instructions were received to turn over to m recorder, J. H. Field, all instructions and engineering property, and report at Sai Louis at the earliest convenience for other duties. The remainder of the observation which were continued till November 25th, were in charge of Mr. Field, who for som time previous had conducted the field-work of the discharge observations.

After the meter came into constant use in March the field-work did not require t full attention of both assistant and recorder. After that date a large part of t assistant's time was occupied in computing discharges and doing other office wor At the time of leaving the work the discharges had been computed up to date, wi the exception of about 8 weeks. The remainder of the computations were made the office under your immediate supervision. At the time of leaving the work no of the notes in connection with velocity curves and cross-section and longitudin soundings had been reduced, excepting one set of longitudinal soundings, which h been plotted and a tracing made.

The success of the work depended largely upon the ability to make the best use the means at hand for accomplishing a particular purpose. The more inadequate t means, the greater the dexterity of judgment required.

The most perplexing problems often presented themselves, inasmuch as the magn tude of the work was probably underestimated in the outset. The greatest exerti was made to obtain the best results possible with the methods employed. Much d pended upon the individual members of the party, who, with few exceptions, we always prompt and true to duty. They were J. H. Field, recorder; H. A. Wilso steersman; W. J. Wilder, engineer; John V. Bandy, A. J. Wilder, and John Q. Hami ton, boatmen.

Respectfully submitted.

J. H. DAVIS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge Observations, Columbus, Ky.

The discharge computations for this station were made in the field, and by the fo lowing method, viz: The cross-sections and positions of velocity observations we plotted on cross-section paper, the cross sections divided into partial sections and the areas determined by counting the squares.

The meter velocities were determined by ratings frequently taken.

Rod float velocities were reduced by Francis' formula. Many of the abrupt chang in area are probably due to change in method of taking observations; a change method usually resulting in a marked change in the number and position of the cros section soundings, and often in the values of the soundings themselves. The large number of soundings were taken in rod-float observations.

The gauge readings on "discharge days" are mean readings for the time occupied taking observations. On "no discharge days" the noon reading is recorded; noo being about the mean time of field observations.

Datum plane was taken at a gauge reading of 102.627 feet.

Datum width, 2,694 feet.

Datum area 191,880 square feet, as observed on February 28.

Datum areas for other days were determined by successively adding and subtracti scours and fills.

Mean depth was determined by dividing *water area* by *water width*, and datum dep by a similar process.

Discharge observations at Columbus, Ky.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1881.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Dec. 8	80.115													
9	79.085	—1.030												
10	78.275	—0.810												
11	77.565	—0.710												
12	76.940	—0.625												
13	76.430	—0.510												
14	76.195	—0.235												
15	76.090	—0.105												
16	76.110	+0.020												
17	76.860	+0.750	126,380	193,467	50.3	71.8	66.4	2,520		3.456	436,711.8	VI 1-2	D. F.	
18	78.045	+1.185												
19	79.490	+1.445												
20	81.352	+1.862												
21	83.740	+2.388	140,560	190,206	55.2	71.3	73.8	2,544	—3,201	5.058	711,020.3	XII 1-2	D. F.	
22	85.463	+1.723	143,390	188,642	56.1	70.0	74.4	2,556	—1,564	5.289	758,170.1	V 1-3	D. F.	
23	86.656	+1.193	148,540	190,737	57.9	70.8	76.8	2,566	+2,095	5.548	824,098.3	III-V 3-6	D. F.	
24	87.776	+1.120	153,260	193,178	59.8	71.7	80.8	2,575	+2,441	5.667	872,062.5	VI 1-2	D. F.	
25	89.211	+1.435												
26	90.931	+1.720												
27	92.302	+1.371												
28	93.176	+0.874	172,090	197,346	65.3	73.3	87.2	2,633	+4,168	6.527	1,123,288.5	XI 5-6	D. F.	
29	93.766	+0.590	174,090	197,790	66.0	73.4	87.9	2,641	+ 444	6.100	1,061,997.5	III 8-10	R. F.	
30	94.026	+0.260	173,370	196,382	65.4	72.9	86.9	2,650	—1,408	6.150	1,066,290.6	II-III 6-8	R. F.	
31	93.956	—0.070	176,730	199,928	66.7	74.2	89.5	2,650	+3,546	6.273	1,108,652.5	V 2-8	R. F.	
1882.														
Jan. 1	93.776	—0.180												
2	93.486	—0.290												
3	93.296	—0.190	180,170	205,115	68.1	76.1	91.2	2,645	+5,187	5.906	1,064,115.1	VI-VII 1-3	R. F.	
4	93.136	—0.160												
5	92.950	—0.186	174,540	200,399	66.1	74.4	95.5	2,640	—4,716	5.753	1,004,202.3	VI 1-2	R. F.	
6	92.786	—0.164	172,720	199,012	65.5	73.9	86.1	2,637	—1,387	5.743	991,908.6	Light.	R. F.	
7	92.446	—0.340												
8	92.196	—0.250												
9	91.816	—0.380	165,810	194,657	63.0	72.3	88.0	2,632	—4,355	5.467	906,540.0	V-VII 1-3	R. F.	
10	91.796	—0.020												

MISSISSIPPI RIVER—*Discharge observations at Columbus, Ky.*—Continued.

Date		Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Method.	Remarks.
1882.		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*				
Jan.	11	92.047	+0.251	168,150	190,389	63.8	72.9	89.0	2,693	+1,793	5.849	949,898.9	VI	1-6	R. F.	
	12	92.519	+0.472													
	13	93.303	+0.784													
	14	94.436	+1.133	172,360	194,278	64.8	72.1	91.5	2,669	−2,111	6.309	1,088,202.0	VII	1-3	R. F.	
	15	95.492	+1.056													
	16	96.190	+0.698													
	17	96.900	+0.710	178,900	194,255	67.1	72.1	92.0	2,669	− 39	7.300	1,316,698.6	V-VI	4-5	M. & R. F.	
	18	97.438	+0.538	183,410	197,320	68.6	73.2	92.0	2,671	+9,074	7.440	1,365,048.8	VI-VIII	1-3	R. F.	
	19	97.934	+0.496	181,610	194,204	69.0	72.1	94.4	2,673	−3,125	7.425	1,348,027.4	VI	3	R. F.	
	20	98.304	+0.370	184,840	196,445	70.0	72.9	95.8	2,673	+5,941	7.402	1,364,950.9	XI	2-1	R. F.	
	21	98.615	+0.311													
	22	98.954	+0.339													
	23	99.268	+0.314													
	24	99.444	+0.176													
	25	99.611	+0.167	179,360	187,459	66.6	69.6	91.5	2,693	−6,906	7.307	1,304,092.8	VI-XI	5-7	R. F.	
	26	99.811	+0.200	182,420	189,980	67.8	70.5	98.0	2,694	+3,521	8.018	1,462,661.7	XI	3-6	R. F.	
	27	99.881	+0.070	184,560	191,932	68.5	71.2	94.8	2,694	+1,952	7.091	1,409,908.5	VII	1-3	M.	Mid-depth only.
	28	100.064	+0.183													
	29	100.011	−0.053													
	30	99.984	−0.027	183,500	190,594	68.1	70.7	91.0	2,695	−1,958	7.407	1,370,900.9	VII	1-3	M.	Do.
	31	100.064	+0.080													
Feb.	1	100.066	+0.002	180,330	187,208	66.9	69.5	91.0	2,695	−9,391	7.614	1,372,945.4	XI	4-6	M. & R. F.	Meter at mid-depth.
	2	100.052	−0.014	174,698	181,609	65.1	67.4	89.0	2,695	−5,694	8.053	1,406,911.6	VI	2-3	M.	Do.
	3	100.027	−0.025	182,160	189,138	67.5	70.2	90.0	2,697	+7,529	7.398	1,347,585.0	VII-VIII	2-3	R. F.	
	4	100.071	+0.044	184,950	191,809	68.6	71.2	89.5	2,697	+2,071	7.725	1,428,752.7	IV-V	6-10	R. F.	
	5	99.973	−0.098													
	6	99.850	−0.114	182,340	189,771	67.5	70.4	91.2	2,701	−2,038	7.247	1,321,504.6	XI	3-10	R. F.	
	7	99.746	−0.113	181,890	189,626	67.4	70.4	87.0	2,699	− 145	7.517	1,366,928.1	XI	3-6	R. F.	
	8	99.552	−0.194	190,940	199,199	70.8	73.9	95.0	2,697	+9,573	7.426	1,417,857.2	IV-V	4-6	R. F.	
	9	99.343	−0.209	188,970	197,792	70.1	73.4	97.5	2,694	−1,407	7.405	1,399,373.0	V	6-7	R. F.	
	10	99.051	−0.292	188,540	198,148	70.1	73.6	93.5	2,689	+ 356	7.035	1,326,304.8	XI	3-7	R. F.	
	11	98.712	−0.339	188,510	199,028	70.2	73.9	94.5	2,684	+ 881	6.840	1,289,452.2	X-XI	5-7	R. F.	
	12	98.331	−0.381													
	13	98.079	−0.252	188,560	200,777	70.3	74.5	95.0	2,682	+1,748	6.594	1,243,445.0	V	3-6	R. F.	
	14	98.056	−0.023	185,020	197,299	69.0	73.2	92.5	2,681	−3,478	6.646	1,229,568.3	VII-XII	2-3	R. F.	
	15	97.856	−0.200	193,260	206,075	71.9	76.5	94.5	2,680	+6,776	6.485	1,253,363.3	VII-XI	3	R. F.	
	16	98.014	+0.158													

	[illegible]	102.[illegible]	+0.[illegible]												
	25	102.666	+0.[illegible]85												
	26	102.801	+0.186												
	27	102.691	−0.110												
	28	102.627	−0.064												
Mar.	1	102.[illegible]67	−0.200	191,880	191,880	71.2	71.2	101.0	2,604	−8,709	8.121	1,558,828.8	VI	3–6	R. F.
	2	102.039	−0.328	182,106	182,800	68.4	67.9	100.5	2,649	−8,990	8.241	1,501,527.0	XII	2	R. F.
	3	101.878	−0.101	189,500	191,123	71.4	70.9	94.0	2,649	+8,238	8.025	1,521,139.6	XII	2	R. F.
	4	101.681	−0.107	188,880	190,809	71.3	70.8	98.0	2,649	− 254	8.039	1,518,454.4	Calm		R. F.
	5	101.455	−0.226	180,510	189,021	70.0	70.2	98.0	2,649	−1,848	7.845	1,463,149.5	X	2–4	R. F.
	6	101.118	−0.337												
	7	100.828	−0.290	186,110	190,114	70.1	70.6	95.5	2,654	+1,093	7.525	1,430,047.8	VI	3–5	R. F.
	8	100.550	−0.278	184,020	188,793	69.3	70.1	89.5	2,653	−1,321	7.625	1,403,204.8	VI	4–6	R. F.
	9	100.401	−0.149	180,650	186,150	68.4	69.1	89.5	2,641	−2,634	7.694	1,389,012.2	Calm		R. F.
	10	100.219	−0.182												
	11	100.052	−0.167	181,830	188,213	68.8	69.9	90.5	2,641	+2,054	7.225	1,323,720.1	VI	3–5	R. F.
	12	100.093	+0.041	178,620	185,444	67.7	68.8	88.5	2,639	−2,769	7.351	1,313,074.9	I	3–4	R. F.
	13	100.188	+0.095												
	14	100.341	+0.153	185,130	191,595	70.0	71.1	92.5	2,644	+6,151	7.350	1,360,649.6	V	3–5	R. F.
	15	100.368	+0.027	185,825	191,885	70.2	71.2	92.5	2,646	+ 290	7.089	1,317,275.1	XI	2–6	R. F.
	16	100.251	−0.117	185,970	191,959	70.3	71.2	89.0	2,646	+ 74	7.425	1,385,773.7	II	3	R. F.
	17	100.089	−0.162	185,790	192,089	70.2	71.3	92.0	2,646	+ 130	7.354	1,366,285.7	VI	2	R. F.
	18	99.821	−0.268	187,640	194,368	70.9	72.1	88.5	2,645	+2,279	7.136	1,338,925.8	X	3–5	R. F.
	19	99.601	−0.220												
	20	99.267	−0.334												
	21	98.805	−0.462												
	22	98.242	−0.563	182,902	193,020	68.7	71.6	84.0	2,635	−1,348	6.387	1,168,218.0	II	5–10	M.
	23	97.456	−0.786	187,465	199,066	71.2	73.9	90.0	2,634	+6,046	6.091	1,141,828.0	IV–I	4–6	M.
	24	96.789	−0.667	182,450	196,120	69.3	72.8	86.0	2,632	−2,946	5.773	1,053,340.3	XI–XII	6–8	M.
	25	96.271	−0.518	183,225	198,650	69.1	73.7	87.0	2,630	+2,530	5.810	1,064,509.2	VI	3–4	M.
	26	95.938	−0.333	176,835	193,621	67.3	71.9	82.0	2,627	−5,029	5.462	965,913.8	XI	3–6	M.
	27	95.938	−0.000												
	28	95.756	−0.182	178,860	196,520	68.1	72.9	82.0	2,625	+2,899	5.596	1,000,966.7	XI–V	5–10	M.
	29	95.796	+0.040	178,865	197,003	68.1	73.1	82.0	2,624	+ 483	5.433	971,713.0	Calm		M.
	30	95.933	+0.137	179,800	197,883	68.5	73.4	82.0	2,624	+ 830	5.510	990,702.4	XI	4–10	M.
	31	96.060	+0.127	180,525	198,198	68.7	73.6	84.0	2,628	+ 365	6.051	1,092,383.0	V–VI	4–7	M.
Apr.	1	96.152	+0.092												
	2	96.076	−0.076	181,430	198,527	69.0	73.7	86.0	2,630	+ 329	5.900	1,070,398.7	XII–XI	3–4	M.
	3	95.889	−0.187												
	4	95.342	−0.547	180,895	198,684	68.7	73.7	86.0	2,631	+ 157	5.941	1,074,721.6	XII	2	M.
	5	94.386	−0.956	178,565	197,792	68.0	73.4	86.0	2,628	− 892	5.753	1,027,330.3		2	M.
	6	92.940	−1.446	177,690	199,428	67.7	74.0	85.0	2,625	+1,636	5.491	975,641.7	XI	2	M.
	7	91.076	−1.864	172,260	197,789	65.8	73.4	84.0	2,619	−1,639	5.220	899,116.8	XII	3–4	M.
	8	89.636	−1.440												
	9	89.382	−0.254	162,480	196,613	62.7	73.0	79.0	2,589	−1,176	4.756	772,834.2	XII	2	M.

MISSISSIPPI RIVER—*Discharge observations at Columbus, Ky.*—Continued.

Date.		Gauge.		Dimensions of cross-section of discharge.												
		Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Method.	Remarks.
				Water.	Below datum.	Mean.	Mean datum.	Maximum.								
1882.		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*							
Apr.	10	89.831	+0.449	164,320	197,948	63.5	73.5	81.0	2,589					5-8	M.	
	11	89.928	+0.097	164,030	197,407	63.3	73.3	80.0	2,590					4-6	M.	
	12	89.941	+0.013	164,740	198,083	63.6	73.5	81.0	2,590					7-10	M.	
	13	89.661	—0.280	161,880	198,948	63.7	73.8	80.0	2,590					4-6	M.	
	14	89.401	—0.260	162,890	197,631	63.0	73.4	80.0	2,590					3-5	M.	
	15	89.386	—0.015	162,910	197,690	63.0	73.4	80.0	2,590					2-3	M.	
	16	89.626	+0.240													
	17	89.946	+0.320	162,335	195,665	62.7	72.6	80.0	2,590					2-3	M.	
	18	89.891	—0.055	163,530	197,063	63.0	73.1	80.0	2,595					2-3	M.	
	19	89.407	—0.484	160,890	195,618	62.1	72.6	77.5	2,591					8-10	R. F.	
	20	88.545	—0.862	156,080	193,936	60.9	72.0	75.0	2,578					2	R. F.	
	21	87.516	—0.999	151,320	193,847	60.0	72.0	78.0	2,570					5-6	M.	
	22	86.757	—0.789	152,090	193,640	59.5	71.9	79.0	2,558	— 207	4.316	656,377.4	XI	2-4	M.	
	23	85.841	—0.916													
	24	85.321	—0.520	148,700	193,909	58.6	72.0	74.0	2,538	+ 269	4.307	640,451.3	Calm		M.	
	25	85.291	—0.030	150,760	196,045	59.4	72.8	75.0	2,538	+2,136	4.367	658,422.2	Calm		M.	
	26	85.723	+0.432	151,870	196,058	59.8	72.8	74.0	2,540	+ 13	4.199	637,731.7	XII	5-8	M.	
	27	86.101	+0.378	150,955	194,184	59.1	72.1	75.0	2,553	—1,878	4.152	626,716.0	VI	3-5	M.	
	28	86.601	+0.500												M.	
	29	86.936	+0.335	153,630	194,722	60.1	72.3	74.5	2,557	+ 542	4.192	644,019.4	VI	6-7	R. F.	
	30	87.186	+0.250													
May.	1	87.411	+0.225	153,530	193,405	59.8	71.8	74.1	2,566	—1,317	4.302	660,526.5	XII	3	R. F.	
	2	87.608	+0.197	154,840	194,209	60.3	72.1	76.0	2,568	+ 804	4.619	715,162.2	VI	2-5	M.	
	3	87.676	+0.068	154,610	193,804	60.2	71.9	77.0	2,570	— 405	4.496	695,135.4	XI	2-3	M.	
	4	87.710	+0.034	158,900	198,007	61.7	73.4	76.0	2,575	+4,203	4.563	724,982.9	XI	2-5	M.	
	5	87.505	—0.205	156,780	196,414	61.0	72.9	76.0	2,572	—1,593	4.434	695,155.8	XI	4-8	M.	
	6	87.211	—0.294	153,840	194,229	59.9	72.1	77.0	2,568	—2,185	4.543	698,859.3	XI	2-3	M.	
	7	86.766	—0.445													
	8	86.310	—0.456	148,520	191,221	57.9	71.0	74.0	2,565	—3,008	3.882	576,578.9	X-XII	1-3	M.	
	9	87.473	+1.163	159,750	199,456	61.8	74.0	76.0	2,585	+8,235	4.770	762,130.2	XI	1-3	M.	Mid-depth only.
	10	90.516	+3.043	161,040	192,869	62.1	71.6	78.0	2,592	—6,587	5.319	856,651.8	I-II	2-4	M.	
	11	92.486	+1.970	170,612	197,324	65.6	73.2	81.5	2,603	+4,455	4.988	850,935.6	I	4-6	R. F.	
	12	94.114	+1.628	171,660	194,129	65.8	72.1	87.0	2,609	—3,195	5.402	927,554.0	V	5-10	R. F.	
	13	95.481	+1.367	181,050	199,942	69.0	74.2	90.0	2,624	+5,813	5.547	1,004,211.9	VI	6-8	R. F.	

	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	XII	[illegible]	M.	Do.
	21	96.411	+0.205					85.0	2,646	−2,645	5.850	1,028,806.7	XI-XII	1-5		
	22	96.049	+0.238	180,130	195,950	68.3	72.7	88.0	2,636	+4,054	6.050	1,089,851.6	V-VI	3-6	M.	
	23	96.081	+0.032	179,060	194,796	67.9	72.3	85.0	2,636	−1,154	6.207	1,111,465.2	XI	1-3	M.	Do.
	24	96.806	−0.286													
	25	95.854	−0.541	178,090	196,006	67.6	72.8	84.0	2,635	+1,210	5.908	1,052,080.2	IV-VII	2-4	M.	
	26	95.053	−0.801	174,900	195,015	66.5	72.4	84.0	2,632	− 901	5.602	960,226.1	XII	1-2	M.	
	27	93.916	−1.137	171,020	194,031	65.2	72.0	81.0	2,621	− 984	5.240	897,691.1	XII	1-2	M.	
	28	93.001	−0.915													
	29	92.285	−0.716	169,680	196,950	64.9	73.1	81.0	2,618	+2,928	5.204	882,966.9	VI	2	M.	
	30	92.286	+0.001	168,090	195,366	64.8	72.5	81.0	2,613	−1,503	5.331	896,046.1	IX-XII	2-4	M.	Do.
	31	93.312	+1.026	172,510	197,104	66.0	73.2	84.0	2,616	+1,738	5.532	954,308.6	XII-I	3-6	M.	Do.
June	1	94.199	+0.887	174,710	196,979	66.5	73.1	86.0	2,626	− 125	5.784	1,010,529.4	V-VII	2-4	M.	
	2	94.951	+0.752	175,450	195,742	66.0	72.7	84.0	2,633	−1,237	5.934	1,041,069.5	X-XII	4-8	M.	
	3	95.525	+0.574	180,610	199,390	68.5	74.0	87.0	2,635	+3,648	5.929	1,070,903.9	I-IV	3-6	M.	
	4	95.980	+0.455													
	5	96.236	+0.256	178,450	195,356	67.6	72.5	86.0	2,637	−4,034	6.159	1,099,027.8	III-IV	2-3	M.	
	6	96.371	+0.135					88.6	2,627				XII	2-3	R. F.	
	7	96.335	−0.036	179,770	196,416	68.4	72.9	86.5	2,627	+1,060	5.468	983,061.7	XII	2-3	R. F.	
	8	96.324	−0.011	179,890	196,565	68.5	73.0	85.5	2,627	+ 149	5.483	986,329.8	XII	2	R. F.	
	9	96.111	−0.213	178,400	195,695	67.9	72.0	86.0	2,627	− 870	5.489	979,648.7	XII	2-3	R. F.	
	10	95.678	−0.433	176,080	194,451	67.1	72.2	86.0	2,622	−1,244	5.667	998,766.4	X-XII	2-3	M.	
	11	95.023	−0.655													
	12	94.228	−0.795	169,640	191,813	65.1	71.2	82.5	2,622	−2,638	5.089	863,363.2	I-II	2-3	R. F.	
	13	93.220	−1.008	170,630	195,435	65.6	72.5		2,600	+3,622	4.942	843,249.2	X-XII	2-4	R. F. & M.	
	14	91.924	−1.296	168,270	196,441	64.9	72.9	80.0	2,593	+1,006	4.603	774,626.5	X-XI	4-6	R. F.	
	15	90.224	−1.700	162,150	194,722	62.8	72.3	78.5	2,584	−1,719	4.380	710,277.9	I-II	2-3	R. F.	
	16	88.955	−1.269	158,990	194,839	61.6	72.3	76.5	2,580	+ 117	4.209	669,270.5	II	1-3	R. F.	
	17	88.083	−0.872	156,010	194,132	60.8	72.1	76.0	2,564	− 707	4.124	643,563.0	X	3-4	R. F.	
	18	88.077	−0.006													
	19	89.252	+1.175	157,080	196,099	60.8	72.8	79.0	2,579	+1,967	4.759	747,593.4	V	3-5	R. F.	
	20	91.096	+1.844	163,180	197,433	63.0	73.3	81.5	2,589	+1,334	4.937	805,696.7	X	1-2	R. F.	
	21	92.356	+1.260	166,240	197,225	64.0	73.2	80.8	2,598	− 208	4.955	823,667.2	XII	2	R. F.	
	22	92.882	+0.526	168,150	197,767	64.5	73.4	81.5	2,604	+ 542	4.947	831,867.1	XII	1-2	R. F.	
	23	93.241	+0.359	168,780	197,462	64.8	73.3	83.0	2,605	− 305	5.385	908,860.9	VIII-XII	2	M.	
	24	93.487	+0.246	166,920	194,961	64.1	72.4	83.0	2,605	−2,501	5.392	900,001.1	X-XII	2-4	M.	Mid-depth only.
	25	93.481	−0.006													
	26	93.249	−0.232													
	27	92.784	−0.465	164,840	194,712	63.3	72.3	83.0	2,604	− 249	4.075	820,010.2	VII-X	2-3	M. & R. F.	
	28	91.968	−0.816	166,990	198,982	64.4	73.9	85.0	2,593	+4,270	5.145	859,207.7	VI	2	M.	Do.
	29	91.378	−0.590	162,900	196,509	63.1	72.9	83.0	2,585	−2,473	4.888	796,650.2	II-VI	1-3	M.	
	30	90.818	−0.560	159,250	194,315	61.7	72.1	83.0	2,580	−2,194	4.823	768,490.1	II-XI	2-5	M.	Do.
July.	1	90.751	−0.067	162,540	197,678	63.0	73.4	83.0	2,580	+3,363	4.935	802,201.7	I-XII	2-5	M.	
	2	91.067	+0.316													
	3	91.192	+0.125	162,420	196,419	63.0	72.9	80.0	2,585	−1,259	5.049	820,058.3	XI-I	1-5	M.	
	4	91.876	+0.684													
	5	92.469	+0.593	170,830	201,521	65.8	74.8	82.0	2,596	+5,102	4.847	828,023.7	III-V	2-4	M.	
	6	93.058	+0.589	169,910	199,070	65.3	73.9	86.0	2,601	−2,451	5.051	858,239.2	IX-XI	2-4	M.	
	7	93.625	+0.567	171,300	198,985	65.7	73.9	84.5	2,601	− 85	5.388	922,963.1	X-XII	4-8	M.	

MISSISSIPPI RIVER. *Discharge observations at Columbus, Ky.*—Continued.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Mean mean.	Width.	Rang of fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
July 8	93.962	+0.337	108,420	105,237	64.2	73.5	60.0	[illegible]	[illegible]	[illegible]	[illegible]	S-XII 0-0	M.	
9	94.031	+0.000												
10	93.788	—0.243	160,170	109,400	66.8	71.8	63.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
11	93.502	—0.286	167,340	106,811	61.4	73.5	60.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
12	92.932	—0.570	168,470	107,900	64.8	70.5	61.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
13	92.075	0.857	160,000	102,411	61.0	71.4	63.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
14	90.883	—1.192	160,750	105,646	62.3	71.0	60.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
15	89.885	—0.998	158,210	105,600	61.0	74.0	78.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
16	89.857	—0.028												
17	88.083	1.774	152,310	101,804	60.7	73.1	78.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
18	87.482	—0.601	150,050	101,673	60.2	71.0	76.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
19	86.716	—0.766	140,000	102,161	58.5	71.0	76.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
20	86.052	—0.664	147,100	104,200	58.4	72.1	77.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
21	85.406	—0.646	144,100	101,650	57.2	71.2	74.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
22	85.095	—0.311	140,6[illegible]0	100,150	56.5	73.8	76.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
23	84.644	0.451												
24	83.898	—0.746	138,000	100,681	55.1	70.7	73.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
25	83.178	—0.720	138,360	103,672	55.7	71.5	72.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
26	82.082	—1.096	131,710	101,741	54.4	71.2	71.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
27	80.981	—1.101	130,510	100,250	54.0	70.6	71.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
28	80.083	—0.898	129,400	101,350	52.0	71.0	68.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
29	79.419	—0.664	126,570	100,161	51.6	70.6	68.0	2,455	[illegible]	[illegible]	[illegible]	IX-XII 1-2	M.	
30	78.876	—0.540	121,950	196,880	49.6	69.4	66.0	2,457	[illegible]	[illegible]	[illegible]	IX-XII	M. & R. F.	
31	78.326	—0.544						2,467				XII	R. F.	
Aug. 1	78.122	—0.204												
2	77.724	—0.398	125,000	193,416	51.1	71.8	65.5	2,457	+6,526	2.566	[illegible]	XII 2-4	R. F.	
3	77.499	—0.225	127,110	195,418	51.7	72.5	65.5	2,456	+2,008	2.536	[illegible]	1-2	R. F.	
4	77.205	—0.291	122,020	191,651	49.8	71.1	64.2	2,462	—3,767	2.4[illegible]0	[illegible]	1-2	R. F.	
5	77.233	+0.028	123,280	192,242	50.1	71.4	64.2	2,461	+ 591	2.566	[illegible]	XII 1-2	R. F.	
6	78.074	+0.841												
7	79.006	+0.932	137,090	201,685	55.6	74.9	72.0	2,464	+9,443	3.052	418,441.8	XI-I 3-4	M.	
8	79.582	+0.576	133,610	199,785	54.2	73.0	72.5	2,466	—4,900	3.143	[illegible]	X-XI	M.	

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,447	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.	
	17	77.869	—0.269	126,740	195,318	51.8	72.5	65.0	2,446	+ 448	2.755	349,172.1	IV-VI	3-5	M.	
	18	77.174	—0.209	126,170	194,259	51.1	72.1	66.0	*2,447	—1,069	2.702	338,172.4	VI	3-4	M.	*Caving bank.
	19	76.921	—0.253	122,250	191,939	50.0	71.8	66.0	*2,451	—2,800	2.714	331,859.4	VI	4-6	M.	
	20	76.551	—0.270													
	21	76.249	—0.302	121,670	193,025	49.7	71.6	67.5	2,447	+1,066	2.598	315,522.0	XII	2	M.	
	22	75.695	—0.554	122,920	196,632	50.1	72.0	65.0	2,451	+2,607	2.263	278,122.4		1	R. F.	
	23	75.268	—0.427	122,380	196,137	50.1	72.8	67.0	2,442	+ 505	2.488	304,462.3	XII	2-3	M.	
	24	74.689	—0.579	121,840	197,010	49.9	73.1	66.0	2,440	+ 878	2.300	280,206.0	IX-II	1-3	M.	
	25	74.045	—0.644	119,100	195,841	46.7	72.7	65.0	2,440	—1,169	2.313	275,498.9	IV-I	1-2	M.	
	26	73.572	—0.473	116,916	194,811	48.0	72.3	64.5	2,438	—1,030	2.234	261,289.2		1-2	M.	
	27	73.007	—0.475													
	28	72.848	—0.249	115,980	195,638	47.7	72.6	65.0	2,433	+ 827	2.144	248,660.8	III-VI	3	M.	
	29	72.573	—0.276	115,080	195,409	47.4	72.5	63.8	2,430	— 229	1.904	219,123.3	VII-X	1-4	R. F.	
	30	72.354	—0.218	115,490	196,349	47.5	72.9	63.5	2,428	+ 940	1.871	216,024.9		1	R. F.	
	31	72.361	+0.007	113,800	194,642	46.8	72.2	62.0	2,428	—1,707	2.124	241,689.4	V-VI	1-3	M.	
Sept.	1	72.354	—0.007	117,180	198,039	48.2	73.5	63.0	2,432	+3,397	2.003	241,703.9	VIII-X	2-3	M.	
	2	72.564	+0.210	115,760	196,108	47.5	72.8	64.0	2,433	—1,931	2.150	248,837.4	III-V	3-4	M.	
	3	72.722	+0.158													
	4	72.844	+0.122	113,130	192,796	46.4	71.6	63.5	2,440	—3,312	2.246	254,074.8	V-VII	3-4	M.	
	5	72.987	+0.143	115,590	194,907	47.4	72.3	64.0	2,440	+2,111	2.192	253,412.9	V-VI	3-4	M.	
	6	73.114	+0.127	116,220	195,227	47.6	72.5	64.5	2,441	+ 320	2.129	247,480.9	V-VI	2-4	M.	
	7	73.404	+0.290	115,800	194,099	47.4	72.0	64.0	2,443	—1,128	2.068	239,471.2	XI-I	2-4	M.	Mid-depth only.
	8	73.689	+0.285	117,580	195,183	48.0	72.5	65.0	2,443	+1,084	2.243	263,716.8		1	M.	
	9	73.849	+0.160	116,230	193,442	47.6	71.8	65.0	2,443	—1,741	2.295	266,755.2	V-VI	2-5	M.	
	10	73.754	—0.095													
	11	73.565	—0.189	117,270	195,176	48.0	72.4	63.0	2,441	+1,734	2.227	261,165.1	IV-VI	3-4	M.	
	12	73.256	—0.309	121,330	190,990	49.7	74.2	63.2	2,440	+4,814	1.927	233,767.8	X-XI	2-4	R. F.	
	13	72.993	—0.263	115,320	194,621	47.3	72.2	63.0	2,438	—5,369	2.127	245,312.6	XII	10-15	M.	
	14	72.544	—0.449	111,780	192,175	45.9	71.3	63.0	2,435	—2,446	2.073	231,768.7	XII-III	3-4	M.	
	15	72.297	—0.247	112,080	193,076	46.1	71.7	62.0	2,433	+ 901	2.045	229,250.4	Calm		M.	
	16	72.051	—0.246	112,180	193,774	46.2	71.9	62.0	2,429	+ 698	2.089	234,325.7	XI-I	2-3	M.	
	17	72.606	+0.555													
	18	73.785	+1.179	118,710	196,084	48.7	72.8	64.0	2,439	+2,310	2.348	278,773.2	XI-XII	3-5	M.	
	19	74.733	+0.948	118,350	193,410	48.5	71.8	64.2	2,442	—2,674	2.228	263,628.4	XI-XII	3-5	R. F.	
	20	75.555	+0.822	122,030	195,078	49.7	72.4	68.0	2,454	+1,668	2.647	322,973.3		1	M.	
	21	75.839	+0.284	121,070	193,421	49.3	71.8	67.0	2,455	—1,657	2.651	320,968.7	IV-VI	4-6	M.	
	22	75.319	—0.520	121,580	195,206	49.6	72.5	65.5	2,450	+1,785	2.512	305,395.3	IV-VI	1-3	M.	
	23	74.322	—0.997	118,830	194,896	48.6	72.3	65.5	2,445	— 310	2.346	278,771.8	III-VI	1-3	M.	Do.
	24	73.664	—0.658													
	25	72.962	—0.702	115,250	194,634	47.3	72.2	63.5	2,435	— 262	2.237	257,810.4	IV-VIII	2-6	M.	
	26	72.142	—0.820	112,360	193,738	46.2	71.9	62.0	2,429	— 896	2.167	243,530.2	VI	3-4	M.	
	27	71.361	—0.781	112,850	196,123	46.5	72.8	62.0	2,425	+2,385	2.034	229,489.7	VI	1-2	M.	
	28	70.521	—0.840	110,440	195,749	45.6	72.7	61.0	2,423	— 374	1.909	217,477.0	XI-XII	3-5	M.	
	29	69.959	—0.562	108,040	194,710	44.6	72.3	60.0	2,421	—1,039	1.899	205,211.7	XI-XII	2-4	M.	
	30	69.675	—0.284	105,480	192,837	43.6	71.6	59.0	2,420	—1,873	1.828	192,780.4	XI-XII	3	M.	
Oct.	1	69.201	—0.474													
	2	68.875	—0.326	104,302	193,594	43.1	71.9	59.0	2,417	+ 757	1.782	185,869.7		1	M.	
	3	68.697	—0.178	103,665	193,387	42.4	71.8	58.0	2,417	— 207	1.829	189,644.9		1	M.	
	4	68.812	+0.115	104,670	194,114	43.3	72.1	58.0	2,415	+ 727	1.548	162,053.9		1	R. F.	

Mississippi River—Discharge observations at Columbus, Ky.—Continued.

Date	Gauge: Reading	Gauge: Rise or fall in preceding 24 hours	Dimensions of cross-section of discharge: Area: Water	Area: Below datum	Depth: Mean	Depth: Mean datum	Depth: Maximum	Width	Scour or fill	Mean velocity per second	Discharge per second	Direction and force of wind		Method	Remarks
	Feet	Feet	Sq. feet	Sq. feet	Feet	Feet	Feet	Feet	Sq. feet	Feet	Cubic feet				
[illegible] 5	68.915	+0.109	105,150	[illegible]	42.0	71.8	58.5	2,419	− 700	1.899	196,145.0		1	B. F.	
6	68.956	+0.026	104,540	[illegible]	41.1	69.9	58.0	2,419	+ 105	1.877	195,809.9	X-XI	2-4	M.	
7	68.799	0.161	105,197	194,692	41.8	72.3	59.0	2,419	+1,159	1.903	199,800.8	I-XI	2-5	M.	
8	68.676	0.123													
9	68.615	0.061	104,580	193,616	42.8	71.8	59.0	2,418	−1,097	1.801	188,592.0		1	M.	
10	68.596	+0.021	103,965	193,814	40.0	72.0	59.0	2,418	+ 919	1.812	188,[illegible]	II-XI	2-4	M.	
11	68.574	0.012	102,650	193,548	42.4	71.5	59.0	2,418	−1,268	1.866	191,541.1	VI	2-3	M.	
12	68.540	+0.076	103,005	192,841	42.0	71.0	59.0	2,418	+ 265	1.963	202,200.1	X-XI	3	M.	
13	68.419	0.209	102,915	193,000	42.5	71.8	59.0	2,417	+ 406	1.868	192,262.9	III-IV	4-5	M.	
14	68.222	0.197	100,455	191,876	41.5	71.0	57.0	2,416	−1,984	1.889	187,007.8	VII-IX	1-2	M.	
15	67.958	0.264													
16	67.732	0.226	98,550	190,066	40.9	70.8	57.5	2,411	− 722	1.821	179,499.9	X-XIII	2-5	M.	
17	67.621	0.111	99,965	193,265	41.5	71.4	58.0	2,407	+1,062	1.884	188,302.0	IV	4-5	M.	
18	67.517	0.104													
19	67.356	0.161	97,425	190,883	40.5	70.7	57.0	2,400	−1,003	1.843	179,451.9	V	5	M.	
20	67.263	−0.093	99,640	192,812	41.4	71.0	57.0	2,409	+2,429	1.769	176,294.6	VI	2-4	M.	
21	67.331	+0.068	100,075	193,003	41.0	71.7	57.0	2,406	+ 281	1.795	179,808.9	VII-VIII	2-3	M.	
22	67.623	+0.292													
23	67.887	+0.264	101,580	193,250	42.0	71.7	58.0	2,421	+ 169	1.875	190,408.9	IV-VI	2-3	M.	
24	68.023	+0.136	101,600	193,007	41.9	71.0	58.0	2,420	− 249	1.929	196,136.0		1	M.	
25	68.021	−0.002													
26	67.961	−0.060	101,115	192,612	41.7	71.5	58.0	2,414	− 395	1.862	188,249.8	XII	3	M.	
27	67.966	+0.005	103,610	195,005	42.7	72.4	58.0	2,425	+2,483	1.848	191,451.4	XII	5	M.	
28	68.055	+0.089	100,840	193,100	41.6	71.3	58.0	2,425	−2,986	1.932	194,845.1	X-XII	4-10	M.	
29	68.208	+0.153													
30	68.328	+0.120	103,370	193,977	42.6	72.0	58.0	2,426	+1,868	1.959	202,458.5	XI-I	10-15	M.	
31	68.316	−0.012	99,790	190,420	41.2	70.7	59.0	2,424	−3,551	1.924	192,031.4	XI-XII	1-2	M.	
Nov. 1	68.391	+0.075	101,295	191,740	41.8	71.2	58.5	2,424	+1,323	1.898	192,280.1	X-XII	3-4	M.	
2	68.557	+0.166	104,570	194,622	43.1	72.2	58.0	2,425	+2,873	1.881	196,715.3	V-VI	3-5	M.	
3	68.729	+0.172	103,355	193,900	42.6	71.6	59.0	2,426	−1,632	2.007	207,441.9	IV-VI	2-3	M.	
4	68.821	+0.092												M.	
5	68.823	+0.002	97,235	186,642	40.1	69.3	57.0	2,426	−6,348	1.925	187,221.4	XI-XII	4-5	M.	Do.
6	68.808	−0.015	102,340	191,788	42.2	71.2	59.0	2,426	+5,141	1.989	203,553.4	XI-XII	10-15	M.	Do.
7	68.735	−0.073	104,240	193,860	43.0	72.0	59.0	2,426	+2,077	1.959	204,215.3	XII	3	M.	

17	70 840	+0. 268	108, 145	192, 693	44. 3	71. 5	60. 0	2, 440	+1, 550	2. 266	245, 057. 5	IV	3–4	M.
18	70. 944	+0. 104	107, 195	191, 489	43. 9	71. 1	61. 5	2, 440	−1, 204	2. 278	244, 154. 3	IV-V	4–5	M.
19	70. 830	−0. 114												
20	70. 596	−0. 234	106, 330	191, 473	43. 6	71. 1	61. 0	2. 438	− 16	2. 255	239, 811. 0	VI	5–8	M.
21	70. 346	−0. 250	107, 740	193, 495	43. 9	71. 8	60. 0	2. 455	+2, 022	1. 759	189, 537. 2	Calm	....	R. F.
22	70. 121	−0. 225	104, 240	190, 547	42. 5	70. 7	59. 6	2, 455	−2, 948	1. 806	188, 250. 8	X	2–3	R. F.
23	70. 039	−0. 082	107, 640	194, 148	43. 9	72. 1	59. 9	2, 452	+3, 601	1. 867	200, 980. 4	III-IV	6	R. F.
24	69. 891	−0. 148	105, 250	192, 120	43. 1	71. 3	59. 8	2, 442	−2, 028	1. 883	198, 215. 9	VI	2–3	R. F.
25	69. 838	−0. 053	105, 365	192, 344	43. 3	71. 4	59. 5	2, 432	+ 224	1. 802	189, 894. 1	IX-X	3	R. F.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 16, 1883.

SIR: In accordance with your letter of April 26 inclosing a copy of a letter from the president of the River Commission, I have the honor to submit the following report as an appendix to my report on the Columbus observations:

The information requested was an opinion as to the relative accuracy, reliability, and economy of the methods of gauging by double floats, by a vertical rod, and by a meter, with suggestions as to improvements in the methods used.

Relative accuracy.—This part of the subject will be considered by first pointing out some of the sources of inaccuracy in the different methods, and then drawing some conclusions as to the adaptability of each to certain conditions.

I. Method by double floats. There are two probable sources of error in this method: first, the necessity of assuming the mean velocity in a vertical plane at some fixed depth, corrected, perhaps, by some given formula; and, second, the possible inability to measure the velocity correctly at the assumed depth.

(1) By an examination of observations made on velocities in a vertical plane, it is found that there is no fixed relation between the velocities at different depths. This is especially the case in silt-bearing streams, such as the Lower Mississippi, where the conditions are so numerous and unstable. Any method of determining a mean velocity in a vertical plane must t[illegible] asuring it in a great number of points in that plane, if perfect a[illegible] ie double-float method, which provides for measuring the velocit[illegible] 1 the vertical, can lay little claim to accuracy, when viewed fr[illegible] point. It is believed that the results, if closely examined, will [illegible] 1 viewed from a practical standpoint. The experiments made [illegible] termining vertical curves, will, when reduced, furnish addition[illegible] subject. It is believed that they will show material variations fr[illegible] relative velocities in a vertical plane, especially where bottom ch[illegible] If so, no method can be relied on for perfect accuracy that take[illegible] small part of the vertical section.

(2) There is also some dou[illegible] acy with which a velocity at any particular depth can be measured [illegible] oat method. During the observations made at Fulton, Tenn., by Ass[illegible] ess, it was my duty for several months to give personal attention [illegible] n of the floats. It gave an excellent opportunity for observing [illegible] water. I was led to believe that at times the surface and sub[illegible] acted upon by almost opposite forces. At times the surface float [illegible] rawn to right or left, in which case it would be considerably incline[illegible] nmersed. Sometimes it would incline backward or forward. In each of these c[illegible] the surface float had a powerful influence in retarding or accelerating the sub-float, the velocity of the former not representing the correct velocity of the water in the vicinity of the latter. The above indications were frequently noticeable in high water. Sometimes also in high water the subfloat was apparently held up, the assumed immersion not being reached. This was shown by the fact that several feet of wire were sometimes taken in before there was any appreciable weight of the subfloat. By an examination of the vertical velocity observations at Fulton, Tenn., it will be found that in the sets in which two or more floats were run at the same depth the velocities differ from 1 to 15 per cent.

In these observations the boat was anchored, and the floats all started from the same point, their paths varying but slightly across the ranges. The Fulton observations have been selected, inasmuch as they are probably the best that have been made with double floats on the Mississippi River

II. Method by rod-floats. Within certain limits of depth the vertical rod is well adapted to measuring the mean velocity accurately, being acted upon by the whole body of water in a vertical plane. Where the float can be run of sufficient length to nearly touch bottom, there is but a small source of error due to the corrections to be made. Where due care is taken in the manipulation, allowing full time for the float to acquire a uniform movement and erect position before entering upon its measured path, little variation should be expected from a series of observations in the same plane. A very small per cent. of variation was found in the observations made with the plant at Grafton, Ill., where six rods of the same length were run from each station. As to the two methods of locating instrumentally, and obtaining the length of path by the plant, used on the Upper Mississippi, the latter is preferable where the depth does not exceed about 25 feet; beyond that depth there is difficulty in putting out the float so as to acquire its equilibrium before entering upon the measured path. A rod-float of more than 35 or 40 feet in length can not be handled successfully. Hence for river depths greater than about 40 feet, the method loses in accuracy. The same objection then comes in that has been presented in connection with double floats, viz., that only a part of the vertical velocity section is measured.

III. Method by the current meter. There is a good deal of room for improvement in the current meter for effective work on the Lower Mississippi. Some improvement has no doubt been made recently in this direction. My experience is confined to the

meter. The chief objection to the method as used by me rests with the instru- itself. The objection presented to the rod-float and the double-float methods not find a place in the method with the meter. It is possible to obtain results l depths in a vertical plane within reasonable limits. The only question that ins is the accuracy with which a velocity can be measured at any particular L Under certain conditions great accuracy may be attained with the Ellis meter. :lear stream, of not too great velocity or depth, the meter, having been carefully ted and rated, will do accurate work, and will continue to so long as the fric- remains constant. It is easily handled, with suitable plant, and can be relied But in such a stream as the Mississippi, at high water, with its great depth and ty, its silt and floating material, the instrument is entirely unsuited to the work. a constant friction cannot be maintained under such conditions can hardly admit oubt to any one who has had an extended experience. There is nothing to pre- he journal-box from catching fine particles of sand, that not only increase the n at the time, but produce a constant wearing effect that results in a perma- increase of friction. The mercury contact, as used at Columbus, is another of variable friction, on account of certain parts of it that catch the sediment, a binding effect being the result. This change of friction can be detected by g the instrument in the wind at frequent intervals during a set of observations. elocity of wind required to turn the wheel will be found to vary materially. A gh cleansing will often remove the difficulty temporarily. These differences of n are not to be found in the equations, as the meter was always rated in clear . The Ellis meter is very delicate, and is subject to be entirely destroyed by g logs. From my experience I think it possible to construct a meter that will e from most of the imperfections mentioned.

re is a considerable source of error in using any meter without anchoring. This ecially the case in windy weather, when it is impossible to avoid lateral move- The rate of the meter is increased by a movement in either direction; hence is no way of compensation. This error is likely to be considerable with a g wind and slow current. For instance, a movement of a hundred feet would e unreasonable, with a brisk wind, during a five-minute observation. That l correspond to about twenty-five revolutions of the meter-wheel, an average of evolutions per minute. If the meter should make but thirty revolutions per te, not an unreasonable supposition, the error would be 20 per cent. Such errors t be practically avoided by locating the position of the boat as frequently as ole, and correcting the velocities accordingly. The error from this source dimin- as the velocity increases.

clusions.—Of the three methods, the double float is considered the least accurate, apable of producing fair results in a stream of even banks and bed. In a clear n of limited depth, the methods by rod-floats and meter are, perhaps, equally ate; when sediment is contained in any considerable quantity, the former of is preferable. At high-water stages on the Lower Mississippi none of the ods can be relied on for perfect accuracy. In extreme high water rod-floats are dered preferable to the Ellis meter. I have no doubt but that a meter may be nstructed and manipulated as to do comparatively accurate work at all stages e Lower Mississippi.

iability.—As to the reliability, the method by rod-floats seems to have the ad- age, although that with the meter may be equally good within limits. From the already presented, the double-float method is considered very unreliable at high- r stages, and reliable only in a limited degree at all stages.

nomy.—When an anchorage, similar to that employed on the Upper Mississippi, e used, the methods by rod-float and current-meter are equally expensive, either eing less so than that by double floats. Free rod-floats and double floats, located umentally, are equally expensive. In high water, when the use of a launch is sary, the method by meter is the cheapest method of all.

suggestions as to improvements will be offered.

spectfully submitted.

J. H. DAVIS,
Assistant Engineer.

rst Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

3.—AT HELENA, ARK., F. A. YEAGER, ASSISTANT IN CHARGE.

HOTCHKISS, TENN., *June* 12, 1883.

R: In reply to your letter containing instructions from president of Commission erning reports, &c., of different methods of gauging, I have to say that I did not k up my notes at Helena, so know nothing of the results. During the latter part y stay there I ran rod-floats and the meter at the same time.

[illegible] accuracy of the methods [illegible] launch. This can be done, wi[illegible] being recorded. The plant is [illegible] skiff. The launch I had at Helena [illegible] and I found it perfectly safe at all tim[illegible] servant,

F. A. YEAGER,
Assistant Engine[illegible]

SIR: In [illegible]
president [illegible]
an appendi[illegible]
The inf[illegible]
and econ[illegible]
meter, w[illegible]
Relativ[illegible]
some of [illegible]
conclus[illegible]
I. Met[illegible]
first, th[illegible]
depth, o[illegible]
to meas[illegible]
(1) I[illegible]
found [illegible]
is exp[illegible]
condi[illegible]
in a [illegible]
in th[illegible]
for [illegible]
acc[illegible]
If [illegible]
Th[illegible]

[illegible] River Commission.

[illegible] discharge observations, Helena, Ark.

[illegible] discharges at Helena, Ark., was as follows:

[illegible] plotted on cross-section paper, and their areas found [illegible] feet horizontal, 20 feet vertical, per square or inch. [illegible] were plotted on the cross-sections, and the area divi[illegible] dividing lines being placed so as to give, as nearly as possi[illegible] partial area, or so that the depth at the velocity positi[illegible] depth of the partial areas.

[illegible] was usually found at a depth considerably less than the m[illegible]

[illegible] *with rod-floats* were corrected and reduced by Francis's fo[illegible]

$$[illegible] = v\left[1 - .116\left(\sqrt{\frac{S-I}{S}} - 0.1\right)\right]$$

[illegible] velocity, v = observed velocity, S = sounding, and I = [illegible]

[illegible] applied as directed in the field-notes.

[illegible] taken at the highest gauge reading, 47.10 feet, on March 8, [illegible] was taken as datum area, and all others obtained by successiv[illegible] scours and fills.

[illegible] means of readings taken at 6 a. m., 12 m., and 6 p. m.

[illegible] by Major Benyaurd.

[illegible] by dividing water area by water width.

[illegible] obtained by dividing datum areas by datum width (= 49.10 fe[illegible]

[illegible] from cross-section soundings in note-books.

[illegible] on which no measurements were made, were derived fro[illegible] plotting the measured widths to gauge.

[illegible] obtained by dividing discharge by water area.

* * * * *

[illegible] "Obs. incomplete" are nearly all computed on cross-sections [illegible] date, corrected for gauge.

[illegible] velocities were also substituted from other dates; especially for part[illegible] of the sections or "end areas."

[illegible] determine the width accurately, the lack of soundings near the riv[illegible] slopes, and the lack of velocity observations near the banks, [illegible] instances, of inaccuracy in the results.

* * * * *

Discharge observations at Helena, Ark.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Dimensions of cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1882.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cubic feet.		°	°		
Jan. 1	38.12	....										No observations taken.	No observations taken.			
2	38.48	+0.36														
3	38.80	+0.32														
4	39.07	+0.27														
5	39.27	+0.20														
6	39.35	+0.08														
7	39.43	+0.08														
8	39.48	+0.05														
9	39.48	0.00														
10	39.40	−0.08														
11	39.35	−0.05														
12	39.33	−0.02														
13	39.43	+0.10														
14	39.53	+0.10														
15	39.65	+0.12														
16	39.92	+0.27														
17	40.30	+0.38	209,777	242,834	43.5	49.5	74.5	4,828	(*)							*No discharge taken.
18	40.70	+0.40														
19	41.08	+0.38														
20	41.38	+0.30														
21	41.70	+0.32	214,497	240,787	44.3	49.0	72.0	4,839	−2,047	5.074	1,088,360				R. F.	
22	41.95	+0.25														
23	42.20	+0.25	217,725	241,591	44.8	49.2	73.0	4,856	+ 804	5.390	1,173,540				R. F.	
24	42.45	+0.25	214,402	237,050	44.0	48.3	73.2	4,871	−4,541	5.367	1,150,695				R. F.	
25	42.65	+0.20	219,282	240,956	45.0	49.1	68.5	4,871	+3,906	5.388	1,181,490				R. F.	
26	42.85	+0.20														
27	43.10	+0.25														
28	43.33	+0.23	219,401	237,763	45.0	48.4	74.8	4,871	−3,193	(*)						*No discharge taken.
29	43.45	+0.12														
30	43.65	+0.20														
31	43.81	+0.16	230,187	246,260	47.3	50.2	78.5	4,871	+8,497	5.593	1,287,435				R. F.	
Feb. 1	43.90	+0.09	232,474	248,060	47.7	50.5	77.8	4,871	+1,800	5.213	1,211,885				R. F.	
2	43.99	+0.09	229,665	244,764	47.1	49.9	78.5	4,871	−3,296	4.971	1,141,665				M.	
3	44.15	+0.16														

MISSISSIPPI RIVER—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.										Temperature, Fahr.			
	Reading.	Rise, or fall in the preceding 24 hours.	Area.		Depth.			Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.			Method.	Remarks.
			Water.	Below datum.	Mean.	Mean datum.	Maximum.						Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Feb. 4	44.35	+0.20	234,138	247,532	48.1	50.4	81.3	4,871	+2,768	4.982	1,166,475	No observations taken.	No observations taken.		M.	
5	44.47	+0.12	....	....												
6	44.65	+0.18	228,528	240,461	46.9	49.0	80.0	4,871	−7,071	4.897	1,119,100				M.	
7	44.80	+0.15	233,834	245,037	48.0	49.9	81.5	4,871	+4,576	5.266	1,231,370				M.	
8	45.15	+0.35	....	....	....	....	....	....	....	....	....				....	
9	45.40	+0.25	241,231	249,511	49.5	50.8	77.5	4,871	+4,474	5.515	1,330,390				M.	
10	45.65	+0.25	....	....	....	....	....	....	....	....	....				....	
11	46.05	+0.40	237,726	242,840	48.8	49.5	84.0	4,871	−6,671	5.541	1,317,240				M.	
12	46.29	+0.24	....	....	....	....	....	....	....	....	....				....	
13	46.58	+0.29	....	....	....	....	....	....	....	....	....				....	
14	46.60	+0.02	240,799	243,234	49.4	49.5	81.0	4,871	+ 394	5.897	1,419,990				M.	
15	46.60	0.00	233,336(?)	235,771	47.9	48.0	74.6	4,871	−7,463	5.778	1,348,215				M.	Observations imperfect.
16	46.57	−0.03	....	....	....	....	....	....	....	....	....				....	
17	46.28	−0.29	235,563	239,557	48.4	48.8	82.0	4,871	+3,786	5.703	1,343,415				M.	
18	46.08	−0.20	233,463	238,431	47.9	48.6	81.4	4,871	−1,126	5.996	1,399,845				M.	
19	46.05	−0.03	....	....	....	....	....	....	....	....	....				....	
20	46.00	−0.05	....	....	....	....	....	....	....	....	....				....	
21	45.85	−0.15	....	....	....	....	81.8	....	....	....	....				....	
22	45.72	−0.13	....	....	....	....	....	....	....	....	....				....	
23	45.66	−0.06	....	....	....	....	....	....	....	....	....				....	
24	45.54	−0.12	221,379	228,977	45.5	46.6	79.8	4,871	+9,454	5.812	1,286,655				M.	
25	45.48	−0.06	224,921	232,811	46.2	47.4	80.2	4,871	−3,834	5.504	1,237,965				M.	
26	45.42	−0.06	....	....	....	....	....	....	....	....	....				....	
27	45.41	−0.01	....	....	....	....	....	....	....	....	....				....	
28	45.52	+0.11	227,977	235,672	46.8	48.0	81.4	4,871	+2,861	5.470	1,247,035				M.	
Mar. 1	45.51	−0.01	....	....	....	....	....	....	....	....	....				....	
2	45.58	+0.07	228,715	236,118	47.0	48.1	83.3	4,871	+ 446	5.427	1,241,235				M.	
3	45.74	+0.16	229,338	235,962	47.1	48.1	78.2	4,871	− 156	5.603	1,284,980				M.	
4	46.06	+0.32	....	....	....	....	....	....	....	....	....				....	
5	46.57	+0.51	....	....	....	....	....	....	....	....	....				....	
6	47.00	+0.43	239,616(?)	240,103	49.2	48.9	83.5	4,871	+4,141	(*)	....				....	* No discharge taken.
7	47.02	+0.02	234,109	234,589	48.1	47.8	84.0	4,871	−5,514	6.432	1,506,375				M.	
8	47.10	+0.08	233,411	233,411	47.9	47.5	86.8	4,871	−1,178	6.677	1,558,485				M.	

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No observations taken.			R. F.	Do.
	17	46.09	−0.18													R. F.	Do.
	18	45.78	−0.30													R. F.	* No discharge taken.
	19	45.72	−0.00													R. F.	Observations incomplete.
	20	45.64	−0.08														
	21	45.45	−0.19														
	22	45.39	−0.06														
	23	45.24	−0.15	220,338.0	229,898	44.9	46.7	81.5	4,871	+ 298							
	24	45.12	−0.12														
	25	45.07	−0.05														
	26	44.98	−0.09														
	27	44.90	−0.08	226,118.2	236,834	46.1	48.2	82.9	4,871	+7,436	6.092	1,877,516.6				M.	Observations incomplete.
	28	44.78	−0.12														
	29	44.66	−0.12	220,831.8	232,217	45.0	47.3	84.2	4,871	−4,617	5.710	1,259,224.8				M.	Do.
	30	44.50	−0.16	220,346.0	233,011	45.0	47.5	84.1	4,871	+ 794	5.929	1,306,362.1				M.	Do.
	31	44.35	−0.15	226,958.3	240,454	46.4	49.0	83.6	4,871	+7,443	5.803	1,317,136.5				M.	Do.
Apr.	1	44.15	−0.02												No observations taken.		
	2	43.98	−0.17														
	3	43.81	−0.17	223,242.5	239,373	45.8	48.8	81.6	4,870	−1,081	5.557	1,240,698.5				M.	
	4	43.64	−0.17	221,586.7	236,736	45.5	48.2	81.4	4,870	−2,637	5.549	1,229,612.7				M.	Observation incomplete.
	5	43.46	−0.18														
	6	43.32	−0.14	218,121.3	234,829	44.8	47.8	81.6	4,870	−1,907	5.546	1,209,618.0				M.	
	7	43.11	−0.21	222,284.6	240,015	45.6	48.9	82.0	4,870	+5,186	5.773	1,287,004.7				M.	
	8	42.85	−0.26	221,047.1	239,986	45.4	48.9	81.7	4,870	− 29	5.483	1,281,986.6				M.	Do.
	9	42.65	−0.20														
	10	42.44	−0.21	217,746.2	238,678	44.9	48.6	82.5	4,854	−1,308	5.098	1,110,116.1				M.	Do.
	11	42.14	−0.30	216,290.0	238,678	44.6	48.6	82.3	4,854	0	5.870	1,161,619.4	I	30		M.	XII=North or up-stream
	12	41.70	−0.44	214,016.2	238,535	44.3	48.6	83.3	4,835	− 143	5.107	1,093,000.9	XII	8		M.	
	13	41.36	−0.34	213,771.1	239,932	44.2	48.9	81.2	4,835	+1,397	5.021	1,073,352.8	XII	4		M.	
	14	41.11	−0.25	212,570.5	239,938	44.0	48.9	80.9	4,835	+ 6	4.814	1,023,256.8				M.	Do.
	15	40.85	−0.26	201,930.5	230,555	41.8	46.9	81.1	4,833	−9,383	4.777	964,668.6				M.	
	16	40.55	−0.30														
	17	40.31	−0.24	197,443.8	228,677	40.9	46.6	79.1	4,830	−1,878	4.845	956,535.0				M.	
	18	40.12	−0.19														
	19	40.02	−0.10	199,248.3	231,883	41.3	47.2	82.1	4,830	+3,206	4.815	959,477.0				M.	
	20	39.86	−0.16	199,736.4	233,143	41.4	47.4	81.4	4,828	+1,260	4.750	948,710.8				M.	
	21	39.66	−0.20	203,780.9	238,153	42.2	48.5	82.2	4,828	+5,010	4.615	940,351.3				M.	
	22	39.30	−0.36														
	23	38.85	−0.45														
	24	38.10	−0.75	187,143.3	229,046	38.8	46.6	77.8	4,828	−9,107	4.449	832,542.7		0		M.	
	25	37.30	−0.80	189,378.0	235,143	39.2	47.9	78.5	4,827	+6,097	4.238	802,550.0	VI	2		M.	
	26	36.40	−0.90	185,263.2	235,372	38.4	47.9	77.1	4,826	+ 229	4.321	800,447.0				M.	
	27	35.62	−0.78	178,217.5	232,090	36.9	47.3	77.1	4,826	−3,282	4.296	765,638.7	I	30–2		M.	
	28	35.16	−0.46														
	29	35.00	−0.16	181,349.1	238,214	37.6	48.5	75.2	4,825	+6,124	4.251	770,844	XII	6		M.	
	30	35.07	+0.07														
May	1	35.05	−0.02	176,972.1	233,596	36.7	47.6	76.2	4,825	−4,618	4.331	766,545.2				M.	
	2	35.02	−0.03	179,711.7	236,480	37.2	48.2	76.1	4,825	+2,884	4.385	788,073.3				M.	
	3	35.08	+0.06	180,034.2	236,514	37.3	48.2	76.2	4,825	+ 34	4.220	759,723.8				M.	Observations incomplete.

MISSISSIPPI RIVER—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			°	°		
May 4	35.10	+0.02	181,064.7	237,448	37.5	48.4	75.9	4,825	+ 934	4.371	791,409.9	VI	4	No observations taken.		M.	
5	35.20	+0.10	183,561.2	239,463	38.1	48.8	76.8	4,825	+2,015	4.362	800,544.5	VI	5			M.	
6	35.23	+0.03															
7	35.30	+0.07															
8	35.43	+0.13	183,420.0	238,213	38.0	48.5	76.2	4,825	−1,250	4.321	792,485.2	VI	4			M.	
9	35.55	+0.12	181,847.0	236,061	37.7	48.1	78.5	4,826	−2,152	4.705	855,516.8	III	5			M.	Do.
10	36.35	+0.80	181,566.4	234,920	38.2	47.8	77.9	4,826	−1,141	4.324	798,030.0		1			M.	
11	37.02	+0.67	186,262.5	233,382	38.6	47.5	78.5	4,828	−1,538	4.620	860,605.6					M.	
12	38.10	+1.08	191,952.0	233,858	39.8	47.6	78.9	4,828	+ 476	4.495	862,978.6	X	30–5			M.	
13	39.05	+0.95	195,793.2	233,112	40.5	47.5	80.2	4,829	− 746	4.628	906,085.2	X	30–3			M.	
14	39.70	+0.65															
15	40.20	+0.50															
16	40.64	+0.44	201,803.0	231,413	41.8	47.1	81.7	4,831	−1,669	5.034	1,015,888.1	X	30–1			M.	
17	40.98	+0.34	211,638.6	239,636	43.8	48.8	80.9	4,833	+8,193	5.093	1,077,877.1					M.	
18	41.25	+0.27	210,231.1	236,924	43.5	48.3	80.5	4,833	−2,712	5.125	1,077,486.6					M.	
19	41.43	+0.18															
20	41.55	+0.12	210,918.0	236,161	43.6	48.1	81.8	4,835	− 763	5.271	1,111,696.1					M.	
21	41.67	+0.12															
22	41.77	+0.10	214,515.7	238,694	44.3	48.6	83.1	4,837	+2,533	5.145	1,103,861.1	XII	4			M.	
23	41.82	+0.05	210,677.7	234,614	43.6	47.8	83.2	4,837	−4,080	5.3'8	1,126,697.1					M.	
24	41.86	+0.04	212,997.5	236,741	44.0	48.2	83.1	4,837	+2,127	5.070	1,080,093.3		0			M.	
25	41.88	+0.02	210,570.7	234,217	43.5	47.7	81.2	4,837	−2,524	5.230	1,101,009.2		0			M.	
26	41.85	−0.03	215,319.0	239,110	44.5	48.7	82.5	4,837	+4,893	5.040	1,086,229.2		0			M.	
27	41.80	−0.05	213,592.5	237,625	44.2	48.4	82.3	4,837	−1,485	5.310	1,145,002.1						
28	41.81	+0.01															
29	41.78	−0.03	215,899.4	240,029	44.6	48.9	83.1	4,837	+2,404	5.048	1,089,962.3	XII	1			M.	
30	41.65	−0.13	210,585.5	235,343	43.6	47.9	82.5	4,835	−4,686	5.300	1,116,826.2						
31	41.49	−0.16															
June 1	41.32	−0.17	215,515.4	241,095	44.6	49.1	83.1	4,834	+5,752	5.082	1,095,271.7		0			M.	
2	41.18	−0.14	212,431.2	238,688	44.0	48.6	83.1	4,833	−2,407	5.010	1,065,217.1					M.	
3	41.10	−0.08	211,389.1	238,033	43.7	48.4	82.0	4,833	− 655	4.930	1,044,232.0	XII	2			M.	
4	41.10	−0.00															
5	41.12	+0.02	210,262.5	236,809	43.5	48.2	82.7	4,833	−1,224	5.035	1,058,616.5					M.	
6	41.19	+0.07															
7	41.27	+0.08															
8	41.32	+0.05	210,000.5	235,580	43.4	47.9	83.3	4,834	−1,229	4.938	1,037,031.3		0			M.	

	10	41.90	−0.09	[illegible]	[illegible]	[illegible]	47.9	82.5	[illegible]	− 39	5.180	[illegible]			M.	
	11	[illegible]	+0.03												M.	
	12	41.85	+0.62	211,078.3	236,510	43.7	44.1	81.1	4,834	+ 990	5.090	1,074,872.7				
	13	41.87	+0.02													
	14	41.29	−0.08													
	15	41.20	−0.09													
	16	41.00	−0.20	212,463.0	239,600	43.9	48.8	78.0	4,833	+3,090	4.843	1,029,055.7			R. F.	
	17	40.65	−0.35													
	18	40.20	−0.45													
	19	39.75	−0.45													
	20	39.20	−0.55	202,358.0	238,669	41.9	48.5	78.1	4,828	−1,431	4.820	958,257.3	VI	1	M.	
	21	38.85	−0.35	194,781.2	232,282	40.8	45.2	78.5	4,828	−5,887	4.845	943,709.4			M.	
	22	38.77	−0.08	197,982.5	235,809	41.0	48.0	78.5	4,827	+3,587	4.717	933,803.0			M.	
	23	38.85	+0.08	194,610.0	232,120	40.3	45.2	78.6	4,828	−3,749	4.727	920,000.4		0	M.	
	24	39.15	+0.30													
	25	39.28	+0.13													
	26	39.45	+0.17													
	27	39.59	+0.14	199,201.0	233,129	41.8	47.4	76.1	4,828	+1,009	4.900	977,850.0			M.	
	28	39.70	+0.11	196,868.0	230,265	40.8	46.8	77.1	4,828	−2,864	4.008	972,318.6			M.	
	29	39.72	+0.02	202,367.0	235,668	41.9	48.0	75.5	4,828	+5,403	4.657	942,482.4	VI	1	M.	
	30	39.66	−0.06	204,015.0	237,600	43.2	48.4	74.7	4,828	+1,932	5.102	1,040,905.0			M.	
July	1	39.52	−0.14	197,936.5	232,556	41.0	47.4	77.2	4,828	−5,044	4.809	951,873.6			M.	
	2	39.45	−0.07													
	3	39.25	−0.20	197,391.0	233,314	40.9	47.5	77.7	4,828	+ 758	4.957	978,522.3			M.	
	4	39.05	−0.20													
	5	38.82	−0.23	193,848.0	231,847	40.2	47.2	76.5	4,828	−1,467	4.993	967,966.7	XII	4	M.	
	6	38.75	−0.07													
	7	38.77	+0.02	196,272.0	234,512	40.7	47.8	76.3	4,828	+2,665	4.836	949,349.6	IV	30–4	M.	
	8	38.87	+0.10													
	9	39.15	+0.28													
	10	39.35	+0.20					76.5								
	11	39.55	+0.20					78.7								
	12	39.70	+0.15	201,314.5	235,064	41.7	47.9	78.9	4,828	+ 552	5.060	1,018,668.3	IX	3	M.	
	13	39.77	+0.07	202,123.0	235,535	41.9	48.0	76.5	4,828	+ 471	4.901	990,590.6			M.	
	14	39.77	0.00	198,284.4	231,696	41.1	47.2	78.7	4,828	−3,839	5.083	1,007,821.2	X	30–2	M.	
	15	39.65	−0.12	199,182.0	233,173	41.2	47.3	77.3	4,828	+1,477	5.164	1,028,504.0			M.	
	16	39.44	−0.21													
	17	39.10	−0.34	196,062.9	232,709	40.6	47.2	78.0	4,828	− 464	4.645	910,702.6			M.	Observation incomplete.
	18	38.63	−0.47	193,743.9	232,658	40.4	47.2	78.5	4,827	− 51	4.681	906,905.5	VI	3	M.	
	19	38.02	−0.61	193,015.8	234,874	40.0	47.7	77.5	4,827	+2,216	4.650	897,617.9			M.	
	20	37.28	−0.74	188,802.9	234,323	39.1	47.5	76.4	4,827	− 551	4.551	859,615.6	XII	2	M.	
	21	36.40	−0.88													
	22	35.35	−1.05	182,628.0	232,547	37.8	47.2	72.5	4,827	−1,776	4.379	799,762.0			M.	
	23	34.48	−0.92													
	24	33.63	−0.80	170,750.2	228,971	35.4	46.4	69.9	4,825	−3,576	4.254	728,155.8			M.	
	25	32.80	−0.83	168,338.9	230,555	35.0	46.8	70.3	4,805	+1,584	4.301	724,029.7			M.	
	26	31.96	−0.84	162,940.9	229,183	34.1	46.5	69.6	4,782	−1,372	4.218	687,350.5			M.	
	27	31.00	−0.96	160,341.8	231,162	33.7	46.9	68.8	4,756	+1,979	4.115	659,771.7	VI		M.	
	28	29.95	−1.05													
	29	28.72	−1.23	146,562.8	228,213	30.9	46.3	67.2	4,745	−2,949	4.069	595,494.3			M.	
	30	27.35	−1.37													
	31	26.25	−1.10	135,537.3	228,866	28.8	46.4	64.5	4,710	+ 653	3.987	540,376.3			M.	

No observations taken.

MISSISSIPPI RIVER.—*Discharge observations at Halena, Ark.*—Continued.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq* [illegible]	[illegible]	[illegible]			°	°		
Aug. 1	25.15	—1.10	130,097.7	228,596	27.7	46.4	62.3	4,689	— [illegible]	[illegible]	[illegible]			No observations taken.		M.	
2	24.25	—0.90	121,583.7	224,292	26.1	45.5	63.7	4,607	— [illegible]	[illegible]	[illegible]					M.	
3	23.52	—0.73	116,071.2	222,182	24.9	45.0	62.5	4,654	— [illegible]	[illegible]	[illegible]					M.	
4	23.06	—0.46															
5	22.58	—0.48	111,135.6	221,614	24.0	44.9	62.1	4,639	— [illegible]	[illegible]	[illegible]2	VI	4			M.	
6	22.15	—0.43															
7	21.85	—0.30	112,047.3	225,910	24.2	45.8	65.3	4,632	+ [illegible]	[illegible]	[illegible]	VI	5			M.	
8	22.00	+0.15	111,532.5	224,700	24.1	45.6	61.8	4,634	— [illegible]	[illegible]	[illegible]	[illegible]	30–2			M.	
9	22.70	+0.70	116,791.2	226,714	25.2	46.0	62.1	4,637	+ [illegible]	[illegible]	[illegible]	[illegible]	3			M.	
10	23.55	+0.85	121,168.8	227,143	26.0	46.1	62.8	4,655	+ [illegible]	[illegible]	[illegible]	[illegible]	2			M.	
11	24.17	+0.62	126,414.7	229,499	27.1	46.5	63.4	4,666	+ [illegible]	[illegible]	[illegible]	[illegible]	0			M.	Observation incomplete.
12	24.47	+0.30	127,815.3	229,499	27.4	46.5	61.1	4,670	[illegible]	[illegible]	[illegible]	[illegible]	1			M.	
13	24.35	—0.12															
14	24.05	—0.30	132,040.8	235,684	28.3	47.8	61.0	4,663	+6,18[illegible]	[illegible]	[illegible]	VII	30–2			M.	
15	23.77	—0.28															
16	23.45	—0.32	119,566.0	226,007	25.6	45.8	62.5	4,662	—9,677	3.816	456,204.4					M.	
17	23.06	—0.39	123,820.0	232,079	26.6	47.1	61.5	4,659	+6,072	{3.879	480,410.0					M.	
										{3.604	453,787.0					R. F.	
18	22.58	—0.48	121,876.0	232,371	26.2	47.1	61.9	4,656	+ 292	3.833	467,209.0	XII	3			M.	
19	22.10	—0.48	119,921.0	232,650	25.8	47.2	60.2	4,653	+ 279	3.646	437,253.0					R. F.	
20	21.65	—0.45															
21	21.35	—0.30	111,757.0	227,974	24.0	46.2	61.8	4,648	—4,676	3.725	416,386.0	VI	1			M.	
22	21.12	—0.23	{111,955.0	229,241	24.1	46.5	62.8	4,643	+1,267	3.768	421,872.0					M.	
			{111,955.0	....	24.1	......	62.8	4,643	......								
23	20.75	—0.37								3.661	409,919.0					R. F.	
24	20.32	—0.43	111,760.0	232,778	24.2	47.2	62.5	4,626	+3,537	3.654	408,545.0					M.	
25	19.85	—0.47	103,987.0	227,177	22.5	46.1	62.5	4,616	—5,601	3.552	369,463.0	IV	30–1			M.	
26	19.25	—0.60	97,387.0	223,343	21.2	45.3	60.6	4,603	—3,834	3.638	354,295.0	XII	1			M.	
27	18.62	—0.63															
28	17.92	—0.70	89,487.0	221,546	19.6	44.9	54.8	4,574	—1,797	3.503	310,446.0	XII	4			M.	
29	17.33	—0.59	92,090.0	226,844	20.2	46.0	58.2	4,562	+5,298	3.528	324,900.0					M.	
30	16.80	—0.53	89,671.0	226,840	19.7	46.0	57.5	4,550	— 4	3.607	323,510.0					R. F.	
31	16.40	—0.40	82,281.0	221,268	18.1	44.5	56.0	4,540	—5,572	3.383	278,376.0	XII	2			M.	
Sept. 1	16.10	—0.30															
2	15.85	—0.25	82,935	222,962	20.7	45.2	57.7	4,000	+1,694	3.347	277,062	XII	1			R. F.	
3	15.74	—0.11															

	9	[illegible]														
	10	16.02	+0.20	84,129	222,455	21.0	45.1	54.8	4,015	[illegible]	[illegible]				M.	
	11	16.25	+0.22													
	12	16.41	+0.16	91,616	230,567	22.8	46.6	55.8	4,020	+7,132	3.466	317,541				
	13	16.34	−0.07													
	14	16.23	−0.09													
	15	15.98	−0.25	89,422	228,818	22.3	46.4	55.4	4,010	− 749	3.699	330,844			M.	Do.
	16	15.67	−0.31	85,446	226,045	22.7	45.8	55.1	3,700	−2,778	3.511	300,043			M.	Do.
	17	15.36	−0.31													
	18	15.05	−0.31	84,250	237,175	22.5	46.1	54.9	3,740	+1,130	3.219	271,255	IV	4	R. F.	
	19	14.90	−0.15	79,443	222,923	21.3	45.2	55.8	3,730	−4,247	3.389	268,888	VI	4	R. F.	
	20	15.25	+0.35	80,379	222,559	21.4	45.1	54.6	3,750	− 369	3.409	274,056	VI	4	R. F.	
	21	16.08	+0.83													
	22	17.10	+1.02	89,381.9	224,006	20.2	45.4	56.2	4,419	+1,447	3.670	328,068.7	XII	4	R. F.	
	23	17.90	+0.80	89,781.3	220,785	19.4	44.8	53.9	4,033	−3,221	3.427	307,639.9	XII	4	M.	
	24	18.20	+0.30													
	25	17.90	−0.30	94,681.8	225,685	20.4	45.8	58.3	4,633	+4,900	3.785	353,595.5	XII		R. F.	
	26	17.30	−0.60	91,098.9	224,879	19.7	45.7	56.7	4,625	− 806	3.630	330,728.8	XII		R. F.	
	27	16.52	−0.78	85,573.8	222,950	18.6	45.2	50.0	4,595	−1,929	3.457	295,803.8	III	2	R. F.	Do.
	28	15.70	−0.82	81,230.4	222,052	21.8	45.0	54.9	3,809	− 898	3.292	267,383.7			R. F.	
	29	14.95	−0.75	79,324.2 79,324.2	222,973 222,973	21.3	45.2	53.9	3,730	+ 921	2.941 3.158	283,281.7 250,517.1			M. R. F.	
	30	14.25	−0.70	76,752.2	222,947	21.6	45.2	53.6	3,546	− 26	3.284	252,034.5		No observations taken.	R. F.	
Oct.	1	13.60	−0.65													
	2	12.00	−0.60	75,278.7	220,065	22.0	44.6	54.0	3,420	−2,882	3.212	241,703.8			R. F.	Do.
	3	12.58	−0.42	72,456.3	218,666	21.5	44.3	53.6	3,357	−1,399	2.798	202,891.8			M.	
	3	12.58	−0.42	72,456.3	218,666	21.5	44.3	53.6	3,357	−1,399	3.097	221,382.2			R. F.	
	4	12.20	−0.38	70,857.9	218,324	21.7	44.3	53.2	3,262	− 842	3.106	220,116.6			R. F.	
	5	11.65	−0.55	70,213.4	219,140	21.7	44.4	52.7	3,226	+ 816	2.959	207,780.2			R. F.	
	5	11.65	−0.55	70,213.4	219,140	21.7	44.4	52.7	3,226	+ 816	2.806	197,052.7			M.	
	6	11.50	−0.15	68,134.5	217,532	22.2	44.1	52.4	3,060	−1,608	2.838	193,010.0			M.	
	6	11.50	−0.15	68,134.5	217,532	22.2	44.1	52.4	3,060	−1,608	2.980	203,015.1			R. F.	
	7	11.50	0	67,359.0	216,757	22.0	43.9	52.0	3,060	− 775	2.759	185,865.7			M.	
	7	11.50	0	67,359.0	216,757	22.0	43.9	52.0	3,060	− 775	2.920	196,700.9			R. F.	
	8	11.50	0													
	9	11.48	−0.02	67,638.6	217,097	22.1	44.0	52.0	3,060	+ 340	2.968	200,420.8			M.	
	9	11.48	−0.02	67,638.6	217,097	22.1	44.0	52.0	3,060	+ 340	2.976	201,260.3			R. F.	
	10	11.37	−0.11	65,014.2	214,809	21.2	43.5	52.5	3,053	−2,288	2.980	193,715.9			M.	
	10	11.37	−0.11	65,014.2	214,809	21.2	43.5	52.5	3,053	−2,288	3.085	197,822.5			R. F.	
	11	11.28	−0.09	65,203.2	215,272	21.4	43.6	52.8	3,037	+ 463	2.926	190,805.7			R. F.	
	12	11.18	−0.10													
	13	11.19	+0.01													
	14	11.12	−0.07	63,660.3	214,215	20.9	43.4	52.4	3,037	−1,057	2.954	188,054.5			R. F.	Do.
	15	11.02	−0.10													
	16	10.90	−0.12													
	17	10.72	−0.18	64,320.3	216,085	21.3	43.8	52.2	3,014	+1,870	2.804	180,361.1			R. F.	
	18	10.60	−0.12													
	19	10.40	−0.20	63,964.9	215,684	21.5	43.7	52.5	2,970	− 401	2.723	174,198.7	XII	5	R. F.	

MISSISSIPPI RIVER.—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge. Reading.	Gauge. Risel or fal in the preceding 24 hours.	mensions of cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq.*				°	°		
Oct. 20	10.08	−0.32	60,733.8	213,403	20.4	43.3	51.3	2,970	−				No observation.		M.	
20	10.08	*0.32	60,733.8	213,403	20.4	43.3	51.3	2,970	−						R. F.	
21	9.85	−0.23	59,538.0	212,891	20.0	43.2	49.5	2,970	−						M.	
21	9.85	−0.23	59,538.0	212,891	20.0	43.2	49.5	2,970	−						R. F.	
22	9.90	+0.05	....	....	....	....	....	....	....						....	* Gauge record for week ending October 28 missing. Taken from Benyaurd report.
23	9.85	−0.05	59,075.0	212,428	19.9	43.1	49.5	2,970	−						M.	Observation incomplete.
23	9.85	−0.05	59,075.0	212,428	19.9	43.1	49.5	2,970	−						R. F.	Do.
24	9.80	−0.05	59,139.5	212,640	19.9	43.1	49.5	2,970	+						M.	
24	9.80	−0.05	59,139.5	212,640	19.9	43.1	49.5	2,970	+						R. F.	
25	9.85	+0.05	59,280.9	212,633	19.9	43.1	49.5	2,970	−						M.	Do.
25	9.85	+0.05	59,280.9	212,633	19.9	43.1	49.5	2,970	−						R. F.	Do.
26	10.05	+0.20	....	....	....	....	....	....	....	....	....	....			....	
27	10.20	+0.15	60,302.8	212,615	20.3	43.1	50.0	2,970	− 18	2.947	177,734.4	....			M.	Do.
28	10.22	+0.02	60,360.7	212,615	20.3	43.1	50.0	2,970	0	3.084	186,138.8	....			M.	
28	10.22	+0.02	60,360.7	212,615	20.3	43.1	50.0	2,970	0	2.828	170,642.9	....			R. F.	Do.
29	10.40	+0.18	....	....	....	....	....	....	....	....	....	....			....	
30	10.35	−0.05	....	....	....	....	....	....	....	....	....	....			....	
31	10.30	−0.05	60,593.0	212,610	20.4	43.1	50.1	2,970	− 5	3.055	185,092.0	....			R. F.	Do.
Nov. 1	10.37	+0.07	....	....	....	....	....	....	....	....	....	....			....	The small area east of sand-bar not included in the November observation.
2	10.48	+0.11	....	....	....	....	....	....	....	....	....	....			....	
3	10.55	+0.07	....	....	....	....	....	....	....	....	....	....			....	
4	10.58	+0.08	....	....	....	....	....	....	....	....	....	....			....	
5	10.67	+0.09	....	....	....	....	....	....	....	....	....	....			....	
6	10.78	+0.11	....	....	....	....	....	....	....	....	....	....			....	
7	10.88	+0.10	....	....	....	....	....	....	....	....	....	....			....	
8	10.90	+0.02	61,920.9	212,155	22.4	43.0	51.9	2,761	− 455	3.328	206,065.5	....			M.	
9	10.92	+0.02	....	....	....	....	....	....	....	....	....	....			....	
10	11.03	+0.11	62,803.8	212,652	22.7	43.1	52.0	2,761	+ 497	3.316	208,229.8	VI			M.	Observat'n incomplete.
11	11.12	+0.09	62,748.9	212,330	22.7	43.0	52.1	2,765	− 322	3.365	211,179.4	VI 4			M.	Do.
12	11.25	+0.13	....	....	....	....	....	....	....	....	....	....			....	
13	11.55	+0.30	....	....	....	....	....	....	....	....	....	....			....	
14	11.75	+0.20	....	....	....	....	....	....	....	....	....	....			....	
15	11.98	+0.23	....	....	....	....	....	....	....	....	....	....			....	

-AT HAYS' LANDING, MISS., HOMER P. RITTER, ASSISTANT IN CHARGE.

—Assistant Ritter has a report in course of preparation, but the necessity for ices in other branches of work has delayed its completion.—S. S. L.

Discharge observations Hays' Landing, Miss.

ling out the accompanying blanks for this station, the mean gauge, water our and fill, mean velocity, discharge, direction of wind and method were from MS. $\frac{792}{c.f.}$, Assistant H. P. Ritter.

erature of the air is the mean of three readings taken each day at 6 a. m., 12 6 p. m. Copied from note-book 890.

a was taken at a gauge reading of 38 feet and a surface width of 2,770 feet.

n *area* for this gauge and width was obtained from the water area of March 15 lying the increase of area due to the difference in gauge readings. This gives um area 169,015 square feet.

n *area* for January 2 was next obtained by adding to the water area of this e area obtained by multiplying the mean of datum surface width and surface of January 2, by the difference between the gauge reading on January 2 and on of datum plane, *i. e.*, 38 feet.

m area, as thus obtained, for January 2=158781.

quent datum areas were obtained by the successive addition or subtraction of urs and fills.

depth was obtained by dividing the water area by the water width.

datum depth was obtained by dividing the datum area by datum width.

mum depth was copied from field notes No. 888, and is the deepest actual sound-en.

for January 2 was obtained by taking the difference between the gauge read-January 1 at 12 m. and the mean gauge for January 2.

r fall between any other two consecutive days is obtained by taking the differ-f the mean guage readings for those days.

In column headed "method"........ { M=Meter. R=Rod floats. D. F=Double floats.

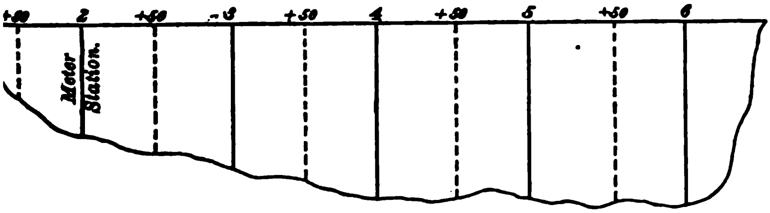
manner of computing partial areas, the manner of dividing the section into areas, and of distributing velocities, is as follows:

mencing at the shore line, the notes read thus—

Station.... .... { 1 +50 2 +50 3 &c.

stations marked 1, 2, 3, &c., are meter stations, while at the other stations ngs only were taken. The first partial area is from 1 to 2+50, the velocity for rtial area being observed at 2.

second partial area is from 2+50 to 3+50, the velocity for this partial area being ed at 3; and so on.



partial areas were computed from the recorded soundings.

of partial area = total area. Partial area multiplied by its velocity = partial rge.

of partial discharges = total discharge.

l discharge divided by total area = mean velocity.

r or fill is the difference between the water area as observed, and that as com-from the change of gauge.

Discharge observations at Hays' Landing, Miss.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Dimensions of cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge [illegible]	[illegible]	Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1882.	Feet.	Fect.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. f[illegible]	[illegible]	[illegible]	[illegible]	°	°		
Jan. 1	29.22	....														
2	29.89	+0.67	136,742	158,781	51.3	49.4	91.8	2,665	....	[illegible]	[illegible]	[illegible]	[illegible]	....	R.	Checked twice.
3	30.30	+0.41														
4	30.70	+0.40														
5	31.05	+0.35														
6	31.39	+0.34														
7	31.58	+0.19														
8	31.78	+0.20														
9	32.00	+0.22														
10	32.14	+0.14														
11	32.25	+0.11														
12	32.40	+0.15														
13	32.63	+0.23														
14	32.70	+0.07														
15	32.80	+0.10														
16	33.08	+0.28														
17	33.25	+0.17														
18	33.48	+0.23														
19	33.70	+0.22														
20	33.99	+0.29														
21	34.28	+0.29	161,534	171,788	59.6	62.0	99.0	2,710	+13,007	6,056	978,300	XII	....	....	R.	
22	34.45	+0.17														
23, 24	34.60	+0.15	154,326	163,699	56.9	59.1	94.7	2,710	− 8,089	5,915	912,805	XII	....	....	R.	
25, 26	35.00	+0.40	155,641	163,944	57.4	59.2	96.7	2,710	+ 245	5,990	932,353	VI	....	....	R.	
27	35.20	+0.20														
28	35.40	+0.20														
29	35.45	+0.05														

[illegible]	[illegible]	+2.15													
5	[illegible]	[illegible]													
6	[illegible]	[illegible]	[illegible]	[illegible], 101	[illegible]	[illegible]	[illegible]	[illegible]	− 1,[illegible]	[illegible]	[illegible]	0			R.
7	36.20	+0.07													
8	36.26	+0.06													
9	36.32	+0.06													
10	36.36	+0.04	165,269	169,820	60.0	61.4	99.0	2,756	+ 4,719	5,862	972,111	0			R.
11	36.41	+0.05	165,563	169,907	60.1	61.4	99.4	2,756	+ 177	6,124	1,012,855	0			R. & M.
12	36.49	+0.08													
13	36.60	+0.11													
14	36.69	+0.09	163,606	167,253	59.4	60.4	98.0	2,756	− 2,742						
15	36.75	+0.06													
16	36.82	+0.07													
17	36.89	+0.07	165,314	168,412	60.0	60.8	101.8	2,756	+ 1,157	5,783	956,066	0			R.
18	36.91	+0.02													
19	37.01	+0.10													
20	37.06	+0.05	165,715	168,344	60.1	60.8	103.0	2,756	− 68			heavy			
21	37.15	+0.09	168,791	171,172	61.2	61.8	101.9	2,756	+ 2,828	6,038	1,019,196	0			R.
22	37.17	+0.02	163,277	165,603	59.2	59.8	100.1	2,756	− 5,560	5,829	951,718	XII			R.
23	37.22	+0.05	167,126	169,329	60.6	61.1	100.2	2,756	+ 3,726	5,842	976,413	0			R.
24	37.27	+0.05													
25	37.38	+0.11													
26	37.42	+0.04													
27	37.52	+0.10	164,729	166,091	59.8	60.0	98.0	2,756	− 3,288			VI			
28	37.64	+0.12													
Mar. 1	37.60	−0.04													
2	37.46	−0.14	169,937	171,478	61.7	61.9	100.0	2,756	+5,387	5,697	968,081	0			R.
3	37.32	−0.14	167,852	169,780	60.9	61.3	99.0	2,756	−1,696	5,684	954,092	0			R.
4	37.18	−0.14													
5	37.10	−0.08													
6	37.07	−0.03	169,328	171,931	61.4	62.1	99.5	2,756	+2,151	5,961	1,009,402	XII			R.
7	37.00	−0.07													
8	37.12	+0.12													
9	37.30	+0.18	171,636	173,605	62.3	62.7	99.0	2,756	+1,674	5,784	984,164	heavy			R.
10	37.30	+0.00													
11	37.30	+0.00													
12	37.48	+0.18													
13	37.64	+0.16	172,024	173,070	62.4	62.5	99.2	2,756	− 535	5,707	961,792	0			R.
14	37.77	+0.13	170,363	171,050	61.6	61.8	100.8	2,765	−2,020	5,448	928,093	VI			R.
15	37.96	+0.19	168,905	169,052	61.0	61.0	102.2	2,770	−1,998	5,588	943,824	0			M.
16	38.17	+0.21	171,870	171,435	62.0	61.9	102.4	2,770	+2,383	5,731	984,950	0			M.
17	38.28	+0.[illegible]	172,157	171,417	62.2	61.9	102.0	2,770	− 18	5,656	973,671	VI heavy			M.
18	38.41	+0.13													
19	38.51	+0.10													
20	38.59	+0.08	172,105	170,513	61.0	61.6	103.8	2,820	− 904	5,444	936,954	VI heavy			M.
21	37.66	−0.93	170,274	171,260	61.8	61.8	103.0	2,756	+ 747			XII			
22	37.10	−0.56	169,262	171,792	61.4	62.0	101.0	2,756	+ 532			XII			
23	36.78	−0.32	169,779	173,205	61.6	62.5	101.5	2,756	+1,413	5,573	946,110	0			M.
24	36.65	−0.13	169,763	173,547	61.6	62.7	102.5	2,756	+ 342	5,539	940,345	0			M.
25	36.50	−0.15													
26	36.40	−0.10													
27	36.31	−0.09													

MISSISSIPPI RIVER.—*Discharge observations at Hays' Landing, Miss.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Mar. 28	36.17	−0.14	167,224	172,331	60.7	62.2	100.4	2,756	−1,216	......	......	0	......	......	......	
29	36.06	−0.11	164,614	170,010	59.7	61.4	101.7	2,756	−2,321	5,557	914,772	VI	......	......	R.	
30	35.95	−0.11	......	......	......	......	......	......	......	......	......	......	......	......	......	
31	35.84	0.11	......	......	......	......	......	......	......	......	......	......	......	......	......	
Apr. 1	35.71	−0.13	......	......	......	......	......	......	......	......	......	......	......	......	......	
2	35.64	−0.07	......	......	......	......	......	......	......	......	......	......	......	......	......	
3	35.53	−0.11	......	......	......	......	......	......	......	[illegible]	[illegible]	[illegible]	[illegible]	......	......	
4	35.46	−0.07	164,760	171,815	60.4	62.0	96.5	2,730	+1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	......	R.	
5	35.39	−0.07	164,067	171,299	60.1	61.8	99.5	2,730	−[illegible]	[illegible]	[illegible]	VI	[illegible]	......	M.	
6	35.30	−0.09	163,855	171,346	60.1	61.9	98.7	2,725	+[illegible]	[illegible]	[illegible]	0	[illegible]	......	M.	
7	35.24	−0.06	163,372	171,026	60.0	61.7	98.5	2,725	−[illegible]	[illegible]	[illegible]	0	......	......	M.	
8	35.15	−0.09	......	......	......	......	......	......	......	......	......	......	......	......	......	
9	35.09	−0.06	......	......	......	......	......	......	......	......	......	......	......	......	......	
10	35.04	−0.05	161,192	169,390	59.5	61.2	99.5	2,707	−1,636	5,404	871,011	0	......	......	M.	
11	34.94	−0.10	......	......	......	......	......	......	......	......	......	......	......	......	......	
12	34.90	−0.04	161,763	170,326	59.7	61.5	99.0	2,708	+ 936	......	......	XII heavy	......	......	......	
13	34.88	−0.02	165,540	174,158	61.1	62.9	101.0	2,708	+3,832	5,566	921,430	XII heavy	......	......	R.	
14	34.83	−0.05	160,424	169,177	59.2	61.1	98.9	2,708	−4,981	5,430	871,112	XII heavy	......	......	R.	
15	34.77	−0.06	......	......	......	......	......	......	......	......	......	......	......	......	......	
16	34.69	−0.08	......	......	......	......	......	......	......	......	......	......	......	......	......	
17	34.62	−0.07	......	......	......	......	......	......	......	......	......	......	......	......	......	
18	34.60	−0.02	164,385	173,773	60.8	62.7	99.2	2,704	+4,596	5,338	877,457	0	......	......	R.	
19	34.59	−0.01	160,656	170,072	59.4	61.4	99.0	2,704	−3,701	6,037	969,866	VI	......	......	M.	
20	34.47	−0.12	166,432	176,159	61.5	63.5	99.5	2,704	+6,087	5,561	925,584	0	......	......	M.	
21	34.44	−0.03	163,664	173,733	60.5	62.6	98.5	2,704	−2,426	5,499	900,034	......	......	......	M.	
22	34.49	+0.05	......	......	......	......	......	......	......	......	......	......	......	......	......	
23	34.46	−0.03	......	......	......	......	......	......	......	......	......	......	......	......	......	
24	34.33	−0.13	......	......	......	......	......	......	......	......	......	......	......	......	......	
25	34.25	−0.08	......	......	......	......	......	......	......	......	......	......	......	......	......	
26	34.15	−0.10	159,935	170,788	59.3	61.6	98.5	2,699	−2,945	5,358	856,940	VI heavy	......	......	M. & R.	
27	34.04	−0.11	161,463	172,613	59.8	62.2	98.0	2,700	+1,825	5,137	829,491	XII heavy	......	......	M. & R.	
28	33.89	−0.15	159,893	171,434	59.2	61.8	99.1	2,700	−1,179	5,181	828,337	0	......	......	M. & R.	

	7	33.69	−0.05														
	8	32.60	−0.00														
	9	31.68	−0.01	156,368	171,162	58.8	61.7	95.0	2,682	− 513	4,282	764,273	VI	very h'vy			R.
	10	32.84	+0.10	160,071	173,485	59.3	62.5	97.6	2,683	+ 2,270	5,087	801,217					R.
	11	32.95	+0.11	159,041	173,112	59.2	62.4	95.8	2,686	− 326	5,207	828,050	IX	light			M.
	12	33.08	+0.13	158,884	172,036	59.1	62.2	96.5	2,687	− 506	5,300	841,851	IX	heavy			M.
	13	33.32	+0.24														
	14	33.55	+0.23														
	15	33.71	+0.16	162,824	174,848	60.3	63.0	99.0	2,701	+ 2,242	5,609	918,842	0				M.
	16	33.85	+0.14														
	17	33.93	+0.08	162,684	174,118	60.2	62.8	97.0	2,703	− 735	5,826	866,310	IX	heavy			R.
	18	33.99	+0.06	161,054	172,823	59.6	62.1	92.9	2,703	− 1,701			0				
	19	34.05	+0.06	162,982	174,101	60.8	62.8	96.7	2,704	+ 1,779	5,671	924,837	0				R.
	20	34.09	+0.04	162,072	173,669	60.1	62.6	90.0	2,705	− 432	5,558	903,247	VI	heavy			R.
	21	34.17	+0.08														
	22	34.16	−0.01														
	23	34.17	+0.01														
	24	34.20	+0.03	164,777	175,489	60.9	63.3	98.5	2,707	+ 1,820	5,555	915,381	XII	light			R.
	25	34.21	+0.01	160,880	171,552	59.4	61.8	98.0	2,707	− 3,937	5,630	905,820	0				R.
	26	34.22	+0.01	164,159	174,804	60.6	63.0	99.8	2,707	+ 3,252	5,574	914,942	VI	light			R.
	27	34.18	−0.04														
	28	34.19	+0.01														
	29	34.17	−0.02	165,931	176,725	61.3	63.7	99.2	2,707	+ 1,921	5,869	973,885	XII	light			M.
	30	34.14	−0.03	166,106	176,981	61.4	63.8	98.8	2,707	+ 256	5,989	994,879	VI	light			M.
	31	34.18	+0.04														
June	1	34.15	−0.03	167,307	178,244	61.8	64.3	98.8	2,707	+ 1,268	6,265	1,048,750	XII	light			M.
	2	34.09	−0.06	166,800	177,796	61.6	64.1	90.9	2,707	− 448	6,062	1,011,169	VI	heavy			M.
	3	34.11	+0.02														
	4	34.12	+0.01														
	5	34.12	0.00	167,449	178,363	61.9	64.3	99.2	2,707	+ 567	6,169	1,033,014	XII				M.
	6	34.12	0.00	168,147	179,062	62.1	64.6	99.8	2,707	+ 699	6,292	1,057,990	XII				M.
	7	34.11	−0.01														
	8	34.13	+0.02	166,955	177,843	61.7	64.1	100.0	2,707	− 1,219	6,133	1,023,999	VI	light			M.
	9	34.14	+0.01	165,809	176,670	61.3	63.7	98.0	2,707	− 1,173	6,249	1,036,221	XII				M.
	10	34.12	−0.02														
	11	34.13	+0.01														
	12	34.12	−0.01														
	13	34.10	−0.02	159,857	170,840	59.1	61.6	97.1	2,707	− 5,830	6,134	980,576	VI	light	85		M.
	14	34.07	−0.03														
	15	34.05	−0.02	161,481	172,509	59.7	62.2	95.2	2,707	+ 1,759	5,976	964,962	VI		83		M.
	16	34.06	+0.01	161,732	172,810	59.7	62.3	96.9	2,707	+ 211	6,188	1,000,769	VI		80		M.
	17	34.03	−0.03														
	18	34.00	−0.03														
	19	33.96	−0.04	161,334	172,682	59.6	62.3	97.8	2,706	− 128	6,222	1,003,772	VI		81		M.
	20	33.94	−0.02														
	21	33.91	−0.03	160,960	172,457	59.5	62.2	95.8	2,705	− 225	6,137	987,833	VI		84		M.
	22	33.89	−0.02	160,111	171,662	59.2	61.9	95.3	2,705	− 705	6,130	981,418	VI	light	85		M.
	23	33.85	−0.04	160,306	171,952	59.2	62.0	96.7	2,706	+ 290	6,159	987,351	0		85		M.
	24	33.81	−0.04														

MISSISSIPPI RIVER.—*Discharge observations at Hays' Landing, Miss.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.										Temperature, Fahr.			
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Air.	Water.	Method.	Remarks.
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
June 25	33.78	−0.03														
26	33.76	−0.02	162,060	173,950	59.9	62.7	95.1	2,704	+1,998			VI light	84			
27	33.75	−0.01	160,546	172,464	59.4	62.2	98.0	2,704	−1,486			VI light	85			
28	33.73	−0.02														
29	33.72	−0.01	160,598	172,618	59.4	62.2	97.5	2,703	+ [illegible]	[illegible]	[illegible]	[illegible] light	85		M.	
30	33.68	−0.04	160,618	172,738	59.4	62.3	97.0	2,702	+ [illegible]	[illegible]	[illegible]	[illegible] heavy	84		R.	
July 1	33.67	−0.01	161,183	173,330	59.7	62.5	96.8	2,702	+ [illegible]	[illegible]	[illegible]	VI heavy.	85		R.	
2	33.63	−0.04														
3	33.57	−0.06	159,416	171,833	59.0	61.9	95.5	2,701	−1,49[illegible]	[illegible]	[illegible]	VI	78		R.	
4	33.50	−0.07														
5	33.45	−0.05														
6	33.38	−0.07	158,069	170,985	58.6	61.6	95.5	2,696	−848	[illegible]	[illegible]02	[illegible]	78		R.	
7	33.34	−0.04	159,912	172,950	59.4	62.3	95.3	2,693	+1,965	[illegible]	[illegible]43	[illegible]	74		R.	
8	33.33	−0.01														
9	33.31	−0.02														
10	33.27	−0.04	157,108	170,321	58.4	61.4	94.5	2,690	−2,629			VI light.	84			
11	33.23	−0.04														
12	33.27	+0.04	158,952	172,151	59.1	62.1	94.0	2,690	+1,830	5.443	865,184	VI heavy.	70		R.	
13	33.23	−0.04	158,177	171,498	58.8	61.8	94.5	2,690	−653	5.645	892,911	VI heavy.			M.	
14	33.18	−0.05	157,111	170,566	58.4	61.5	93.8	2,689	−932	5.599	879,704	0			R.	
15	33.16	−0.02	158,171	171,694	58.8	61.9	92.0	2,690	+1,128	6.035	954,633	VI light.			M.	
16	33.14	−0.02														
17	33.13	−0.01	159,337	172,926	59.3	62.3	91.5	2,689	+1,232			VI				
18	33.14	+0.01	160,832	174,395	59.8	62.9	96.0	2,690	+1,469	5.732	921,865	VI			M. & R.	
19	33.08	−0.06	160,683	174,421	50.8	62.9	97.0	2,689	+26	5.749	923,814		83		M.	
20	33.02	−0.06	161,236	175,135	60.1	63.1	95.0	2,685	+714	5.744	926,115	0	85		M.	
21	32.92	−0.10	160,958	175,125	59.9	63.1	94.1	2,685	−10			0	82			
22	32.82	−0.10														
23	32.64	−0.18														
24	32.29	−0.35	158,672	174,514	59.3	62.9	93.5	2,675	−611			XII	83			
25	32.00	−0.29	156,293	172,924	58.2	62.3	93.9	2,674	−1,590	6.024	941,545	XII heavy.	82		M.	
26	31.55	−0.45	155,126	172,947	58.1	62.3	92.9	2,671	+23	5.830	904,391	XII heavy.	80		M.	
27	31.13	−0.42	154,475	173,430	57.9	62.5	92.9	2,667	+483	5.570	860,474	VI heavy.	79		M.	
28	30.65	−0.48	153,223	173,444	57.5	62.5	93.0	2,664	+14	5.404	828,028	VI heavy.	78		M.	
29	30.09	−0.56														
30	29.32	−0.77														

	6	21.61	−0.87	......	......	......	......	......	......	......	......	......	......		......	......	......
	7	20.52	−1.09	......	......	......	......	......	......	......	......	......	......		......	......	......
	8	19.76	−0.76	123,818	172,234	47.4	62.1	78.5	2,601	−1,995	3.846	474,844	VI	heavy.	81	......	M.
	9	19.10	−0.66	121,595	172,240	46.8	62.1	79.0	2,599	+ 6	......	......	VI	light.	81	......	......
	10	18.83	−0.27	119,589	170,873	46.0	61.6	78.5	2,599	−1,367	4.116	492,048	XII	heavy.	77	......	M.
	11	18.81	−0.02	119,596	170,995	46.0	61.6	77.7	2,599	+ 122	4.267	510,837	XII	light.	78	......	M.
	12	19.10	+0.29	......	......	......	......	......	......	......	......	......	......		......	......	......
	13	19.46	+0.36	......	......	......	......	......	......	......	......	......	......		......	......	......
	14	19.66	+0.20	......	......	......	......	......	......	......	......	......	......		......	......	......
	15	19.70	+0.04	124,152	173,224	47.7	62.4	80.0	2,601	+2,229	3.995	496,043	VI		85	......	R.
	16	19.63	−0.07	124,049	173,303	47.7	62.5	83.5	2,601	+ 79	3.916	485,826	VI	heavy.	84	......	R.
	17	19.47	−0.16	123,542	173,225	47.5	62.4	80.0	2,599	− 78	4.015	495,977	VI	light.	84	......	R.
	18	19.45	−0.02	122,903	172,638	47.3	62.2	78.9	2,599	− 587	3.860	474,445	XII	heavy.	81	......	R.
	19	18.86	−0.59	......	......	......	......	......	......	......	......	......	......		......	......	......
	20	18.40	−0.46	......	......	......	......	......	......	......	......	......	......		......	......	......
	21	18.03	−0.37	119,083	172,502	46.0	62.2	78.9	2,589	− 136	......	......	XII	light.	78	......	......
	22	17.60	−0.43	117,282	171,800	45.4	61.9	77.7	2,586	− 702	4.181	490,380	XII	light.	84	......	M.
	23	17.18	−0.42	......	......	......	......	......	......	......	......	......	......		......	......	......
	24	16.91	−0.27	113,680	169,982	44.0	61.3	76.9	2,582	−1,818	......	......	VI	light.	79	......	......
	25	16.46	−0.45	......	......	......	......	......	......	......	......	......	......		......	......	......
	26	16.06	−0.40	113,603	172,111	44.0	62.0	75.4	2,579	+2,129	3.677	417,741	VI	light.	80	......	R.
	27	15.77	−0.29	......	......	......	......	......	......	......	......	......	......		......	......	......
	28	15.27	−0.50	......	......	......	......	......	......	......	......	......	......		......	......	......
	29	14.60	−0.67	109,434	171,672	42.9	61.9	74.0	2,548	− 439	3.472	379,981	......		81	......	R.
	30	13.90	−0 70	106,725	170,745	42.0	61.6	73.9	2,541	− 927	3.836	356,006	VI	light.	79	......	R.
	31	13.33	−0.57	105,497	170,961	41.7	61.6	72.4	2,529	+ 216	3.283	346,835	0		85	......	R.
Sept.	1	12.57	−0.76	103,149	170,533	40.9	61.5	71.0	2,522	− 428	3.172	327,229	VI	heavy.	82	......	R.
	2	12.20	−0.37	......	......	......	......	......	......	......	......	......	......		......	......	......
	3	11.75	−0.45	......	......	......	......	......	......	......	......	......	......		......	......	......
	4	11.41	−0.34	......	......	......	......	......	......	......	......	......	......		......	......	......
	5	11.11	−0.30	......	......	......	......	......	......	......	......	......	......		......	......	......
	6	10.93	−0.18	97,374	168,872	39.0	60.0	69.2	2,495	−1,661	3.188	310,410	XII	light.	82	......	R.
	7	10.79	−0.14	97,104	169,001	39.0	60.9	68.5	2,493	+ 129	3.104	301,411	XII	light.	83	......	R.
	8	10.69	−0.10	96,896	169,042	38.9	60.9	69.2	2,490	+ 41	3.171	307,288	XII	heavy.	79	......	R.
	9	10.63	−0.06	97,459	169,767	39.2	61.2	68.2	2,489	+ 725	3.202	312,069	XII	heavy.	76	......	R.
	10	10.67	+0.04	......	......	......	......	......	......	......	......	......	......		......	......	......
	11	10.73	+0.06	98 277	170,324	39.5	61.4	71.0	2,489	+ 557	......	......	0		74	......	......
	12	10.85	+0.12	97,864	169,125	39.1	61.0	69.5	2,490	−1,199	3.817	322,995	0		79	......	M.
	13	11.00	+0.15	98,772	170,147	39.6	61.3	69.0	2,496	+1,022	3.564	352,016	VI	light.	78	......	M.
	14	11.13	+0.13	98,065	170,015	39.6	61.3	70.9	2,497	− 132	3.403	330,748	0		83	......	M.
	15	11.19	+0.06	101,374	172,273	40.6	62.1	71.2	2,497	+2,258	3.602	365,182	0		78	......	M.
	16	11.12	−0.07	100,458	171,545	40.2	61.8	70.0	2,497	− 728	3.590	360,643	0		80	......	M.
	17	10.95	−0.17	......	......	......	......	......	......	......	......	......	......		......	......	......
	18	10.74	−0.21	97,954	169,989	39.3	61.3	69.5	2,491	−1,556	3.510	346,726	VI		81	......	M.
	19	10.41	−0.33	97,609	170,452	39.3	61.4	69.0	2,463	+ 463	3.496	341,255	VI	light.	88	......	M.
	20	10.12	−0.29	96,881	170,456	39.1	61.4	68.9	2,477	+ 4	3.446	333,835	VI	light.	82	......	M.
	21	9.91	−0.21	94,829	168,912	38.3	60.9	68.4	2,476	−1,544	3.280	311,026	XII	light.	77	......	M.

MISSISSIPPI RIVER.—*Discharge observations at Hays' Landing, Miss.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Sept. 22	9.94	+0.03														
23	10.36	+0.42	96,077	169,044	38.7	60.9	69.5	2,482	+ 132	3.193	306,767	XII heavy.	69	......	R.	
24	11.06	+0.70														
25	11.70	+0.64	100,640	170,264	40.1	61.4	71.0	2,508	+1,220	3.451	347,330	VI light.	72	......	R.	
26	12.23	+0.53														
27	12.34	+0.11	103,007	171,035	40.9	61.7	73.0	2,520	+ 771	3.270	336,835	0	73	......	R.	
28	12.14	−0.20	102,019	170,538	40.6	61.5	71.3	2,513	− 497	3.182	324,584	VI light.	76	......	M.	
29	11.65	−0.49	101,975	171,723	40.7	61.9	71.0	2,507	+1,185	3.015	307,426	VI light.	80	......	M.	
30	11.00	−0.65	97,857	169,231	39.2	61.0	69.9	2,498	−2,492	3.008	294,313	VI light.	75	......	M.	
Oct. 1	10.32	−0.68														
2	9.70	−0.62	96,277	170,880	39.0	61.6	69.0	2,469	+1,649	3.055	294,127	XII light.	76	......	M.	
3	9.05	−0.65	95,010	171,210	38.9	61.7	70.1	2,445	+ 330	2.913	276,771	0	76	......	M.	
4	8.33	−0.72														
5	7.88	−0.45	93,388	172,445	38.6	62.2	68.5	2,419	+1,235				77	......		
6	7.35	−0.53	90,891	171,217	37.7	61.7	67.4	2,414	−1,228	2.692	244,683	III heavy.	74	......	M.	
7	6.92	−0.43	88,874	170,234	37.0	61.4	66.8	2,399	− 983	2.701	240,075	XII	75	......	M.	
8	6.59	−0.33														
9	6.47	−0.12														
10	6.41	−0.06	89,032	171,614	37.2	61.9	66.9	2,392	+1,380	2.605	231,909	XII light.	81	......	M.	
11	6.49	+0.08														
12	6.56	+0.07	87,980	170,201	36.8	61.4	65.8	2,394	−1,411			0 clear.	79	......		
13	6.60	+0.04	89,035	171,174	37.1	61.7	65.9	2,394	+ 971	2.623	233,574	XII heavy.	75	......	M.	
14	6.38	−0.22	88,834	171,488	37.1	61.8	65.9	2,394	+ 314	2.627	233,353	XII light.	76	......	M.	
15	6.27	−0.11														
16	6.22	−0.05														
17	6.22	0.00	88,070	171,106	36.8	61.7	65.9	2,390	− 382	2.284	201,115	0	72	......	M.	
18	6.29	+0.07														
19	6.25	−0.04														
20	6.18	−0.07														
21	6.20	+0.02														
22	6.25	+0.05														

4	6.09	+0.04	86,411	169,773	36.2	61.2	65.2	2,388	− 486	2.552	220,542	XII	light.	61	......	......
5	6.11	+0.02	......	......	......	......	......	......	......	......	......	......		......	......	M.
6	6.19	+0.08	86,365	169,488	36.2	61.1	65.8	2,389	− 285	2.609	225,358	0		60	......	M.
7	6.22	+0.03	86,625	169,676	36.3	61.2	65.4	2,389	+ 188	2.636	228,312	0		71	......	M.
8	6.24	+0.02	86,970	169,973	36.4	61.3	65.0	2,389	+ 297	2.566	223,143	VI	light.	71	......	M.
9	6.31	+0.07	88,590	171,402	37.1	61.8	65.2	2,391	+1,429	2.608	231,001	VI	heavy,	71	......	M.
10	6.36	+0.05	86,211	168,915	36.0	60.9	66.1	2,392	−2,487	2.606	224,700	VI	very h'vy.	73	......	M.
11	6.40	+0.04	87,270	169,890	36.5	61.2	66.1	2,392	+ 975	2.632	229,735	VI	very h'vy.	69	......	......
12	6.45	+0.05	......	......	......	......	......	......	......	......	......	......		......	......	......
13	6.68	+0.23	86,911	168,866	36.3	61.0	66.1	2,395	−1,024	2.750	239,025	XII	very h'vy.	47	......	M.
14	6.78	+0.10	89,076	170,780	37.2	61.6	66.2	2,396	+1,914	2.735	243,652	VI	light.	46	......	M.
15	7.04	+0.26	89,635	170,715	37.3	61.6	67.1	2,402	− 65	2.803	251,272	0		55	......	M.
16	7.32	+0.28	87,857	168,276	36.5	60.7	66.9	2,407	−2,439	2.861	251,379	0		55	......	M.
17	7.65	+0.33	89,353	168,964	37.0	61.0	67.0	2,416	+ 688	2.918	260,730	XII		55	......	M.
18	8.01	+0.36	90,191	168,931	37.2	61.0	67.5	2,425	− 33	......	......	XII	heavy.	46	......	......
19	8.43	+0.42	......	......	......	......	......	......	......	......	......	......		......	......	......
20	8.66	+0.23	91,219	168,387	37.3	60.8	68.1	2,448	− 544	3.014	274,945	XII	heavy.	41	......	M.
21	8.95	+0.29	92,904	169,362	37.9	61.1	68.5	2,450	+ 974	3.067	284,909	XII	light.	44	......	M.
22	9.11	+0.16	93,556	169,623	38.1	61.2	68.8	2,453	+ 261	3.091	289,149	VI	heavy.	47	......	M.
23	9.34	+0.23	94,308	169,797	38.3	61.3	69.8	2,462	+ 174	3.103	292,665	XII	light.	50	......	M.
24	9.46	+0.12	93,746	168,952	38.0	61.0	69.5	2,465	− 845	......	......	XII	light.	49	......	......
25	9.54	+0.08	......	......	......	......	......	......	......	......	......	......		......	......	......

1. [illegible] LANDING AND HEAD OF THE ATCHAFALAYA, JOHN EWENS, ASSISTANT IN CHARGE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 16, 1883.

SIR: I have the honor to inform you that, in accordance with your instruction, I left Saint Louis with my party for Red River Landing, Louisiana, on November 26, 1881. I arrived at my destination with party on the morning of December 3, 1881. Preparations were immediately made for beginning the discharge work. Everything else was sacrificed to meet this end, as I desired to obtain as large a range of discharge measurements at the different stages of the river as possible. In view of this objective, the elaboration of details of the other work was left until the discharge work was fully inaugurated. On day of arrival, an exhaustive reconnaissance was made for the purpose of selecting suitable discharge sections. After sounding a number of sections, a section located about 200 feet below the warehouse at Red River Landing was selected for gauging the Mississippi. The section for gauging the Atchafalaya is located at Merrick, about 3,000 feet from head of the river. The section in Old River is situated about one mile from its juncture with the Mississippi. The section on Red River is situated about $1\frac{1}{4}$ miles from its passage into Old River. All of these sections presented the usual a[illegible]of a good discharge section, the foremost among which w[illegible]om from eddies and other disturbing elements. The sectio[illegible] velocity curve work was located in "Brunette Bend," 21 mil[illegible]ng and 3 miles above New Texas. The regular serial work co[illegible] necessitated the gauging of the Mississippi daily with but one [illegible]ion being the day allotted each month for work in the bend. [illegible] to be gauged not less than once a week, and daily with the [illegible] The party succeeded in gauging both rivers daily during the e[illegible]rivers reached the ordinary stage, the Atchafalaya was gauged [illegible]ught to be sufficient. In connection with the work mentioned [illegible]ged Red and Old Rivers, also Bayou des Glaises. During the fl[illegible]and Bayou des Glaises were examined. The bend section was wo[illegible]tions to perform bend work were not given the party until so[illegible]g the field. Observations were taken in Old River as often as [illegible] the direction of flow with reference to the Mississippi. The [illegible]pletely and successfully not only the detail work given above, [illegible] of additional work, such as rating meters, making experim[illegible] meter with other plans, &c. The amount of field-work done may b[illegible]mmarized as follows: A total of 310 discharges were measured, 227 of which were measured on the Mississippi, 78 on the Atchafalaya, 3 on Old River, 1 on Red River, and 1 on Bayou des Glaises; the bend section was worked 6 times; a large number of vertical curves of velocity were also taken. The work of establishment having been completed, the regular discharge work was begun on December 13th, 1881, and continued without interruption from this date until the close of the work in November, 1882. The work during the great flood was carried on under the most adverse circumstances imaginable. The observing stations had to be built above the water; the transit station was built in water over ten feet deep. The platforms for the observers at the lining-in stations were built in trees. By working in this manner, the party continued the work without interruption during the entire flood, thus securing a complete and reliable set of discharge observations which will be of inestimable value, as they cover the greatest flood discharge ever measured on the Mississippi River. It was the intention originally to do all the velocity work with the meter, but the late arrival of the steam launch, and some unavoidable delays, caused by losing some of the connecting parts of the meter, made it necessary to resort to float methods until the meter could be employed permanently. The regular plan of conducting the discharge work was as follows: The cross-section was first sounded. Every sounding was located by an angle deflected from a 1,000-foot base-line situated at right angles to the cross-section line. Between 90 and 100 soundings were taken daily. The soundings were taken from the launch, the launch running up above the section line, then drifting back to take the sounding. When above the line, the recorder on board held a signal flag above his head until on exact line, when it was dropped quickly, this being the signal for the transit-man on shore to take the angle locating the sounding. On every tenth sounding a red flag was raised, as a check on the work of shore and launch party. The tangent of each angle was worked out as it was taken, thus giving the distance apart of the soundings, and showing at once any gaps that might exist. By this means, errors were eliminated at once in the field. This system of sounding should be regarded as conventional. I can conceive of no other plan equal to it, as you locate each sounding just where the leadsman happens to cast his lead. And where such a large number of soundings are taken as at the Red River Landing station, you will during a series of days' work touch nearly all points of the section. If the fixed signal system were employed, you

...ash simply the same stations and you know nothing of the changes that are taking place between them. For sounding at this station, light leads and lines were used in preference to the usually heavy ones employed.

The velocity work with floats was performed in the following manner: The floats were timed over a 100-foot path; the transit of float over the ranges inclosing this path was located with transit, the bases of location being 1,000 and 1,100 feet for upper and lower ranges respectively. At the section lines a very satisfactory substitute for transits to line the floats was used. It consisted of fine silk threads, weighted with lead plumb bobs and suspended from the apex of tripods erected over the lining hubs of the sections. These threads gave a line I consider practically as good as that given by the cross hairs of a transit. These stations were established on both banks, half of the river being observed from each bank; there were days, however, when the atmosphere was clear enough to take all the observations from one bank. At each of the lining-in stations, a rude stand was erected for holding the electric key and recording. The floats were all started from points located on a section 500 feet above the upper extremity of the float path. This section was divided into a sufficient number of stations to cover all the velocities between the banks; the angles corresponding to these stations were calculated, so that to start the float, it was necessary simply to run out this section line until the line indicated by signal from the transit-man was reached. At this point the float starter would launch the float; the depth of immersion of float was always determined from soundings taken previously. Double floats were always run at mid depth. Rods were run as close to the bottom as possible. After the float was launched, the boat party followed the float over the path and noted very closely its action; if anything unnatural was visible, the float was always repeated until a visibly satisfactory observation was obtained. To avoid confusion, a system of signals for repeating floats was adopted. When a float was to be repeated for reasons discovered by the boat party, the float starter indicated the fact by waving a flag. When a float was to be repeated for reasons discovered by the shore party, the transit-man waved a flag. The transit of the float over the sections at extremity of path was signaled to the transit-man by telegraph, by the observer at the lining stations, the observer also acting as time-keeper. For a brief time when the flood was at its height, the locations at path extremities were omitted, and a float path of 100 feet was assumed. The washing away of the telegraph supports necessitated this change.

When rods were used, a special form of rod had to be devised, as at the deeper portions of the sections, the weight attached to rod has to be so great that it is necessary to arrange the attachments in such manner that the weight may be detached before withdrawing the rod. If such an arrangement is not made, you will, in a majority of cases, break your rod. If you attempt to make your rod heavy enough to prevent breaking, you will find it will be too cumbersome to handle in a boat. The form of rod devised for this work was the same as that shown in sketch "A." The lower extremity of this rod is made T-shaped, as at "R." To the weight "w" two pan-shaped metallic wrists are attached at vv. These strips fit closely to the T portion of the rod, as shown in the figure. The terminal ends spring outward at cc' for reasons that will presently be given. A string passes from the weight at "h" to the top of the rod. This string is the one used in raising the weight. The small ring at zz' is held by two ring strings that pass from this ring to the top of the rod. The method of launching and withdrawing the rod is as follows: The rod is taken in tow by the skiff. The launching station having been reached, the weight is attached by simply fitting the weight into the groove at "s" and turning the wrists down on the T portion of the rod, making them fast by springing the ring over the spring ends as at gg'. This being done, the rod is lowered gradually into the water until the desired immersion is reached. After the observation is complete, to withdraw the rod, it will be simply necessary to give a brisk jerk on the ring strings, which will set the rod free. As the rod is held by party in the boat the weight pressing downward will throw back the wrists which are hinged at bb'. The weight having been detached, you will find that the rod will shoot rapidly upward and lie flat on the water surface, before the lead weight can be drawn to the surface. While one of the boat crew is raising this weight, the other members of the crew will have taken the float in tow and reached the next station, without loss of time, breakage, or any inconvenience whatever. So it is seen the launching of this type of float is reduced simply to a minimum as to time.

The work with the meter was all conducted from the catamaran. The location was done by intersecting signals established on the bank. This system of location was necessitated by reason of the entire force having duties on the river. The plan of working was as follows: The catamaran was lashed to the launch in such a manner that, the suspending wire holding the meter, the throttle valve of engine and the engineer would all be in plane of the section when on line; the pilot taking such a position with reference to the intersecting signals as to bring the meter exactly on the station. This plan enabled the pilot and engineer to keep the plant in perfect position without any appreciable variation. The greater number of the discharge

velocity observations were taken by holding the plant up against the current. It was found by making a large number of experiments with plant anchored, that the results taken with the plant free or anchored did not differ. Experiments were made frequently at the various stations in order to fully satisfy myself that the plans did not differ appreciably. In doing the work by holding up, care was always taken to commence and end the observations on exact line. The vast amount of time it would take to withdraw and cast large anchors, the continued presence of passing boats and the vast fields of drift that are present in the river continually at flood stages necessitated the adoption of this plan.

In taking vertical velocity-curve observations, the plant was always anchored. The meter was worked from the stern of the catamaran. The connection and general arrangement of the apparatus was as follows: The suspending and guy-wires were attached to two model cog-reels which were attached to the platform, in the bow and stern respectively. The suspending wire passed from the stern-reel over to an iron sheave held by a pulley stanchion that projected about 4 feet upwards from end of the stern; this stanchion leaned outward far enough to let the meter weight clear the platform. The wire passed from this sheave to the loop-clasp of the meter-weight pipe. The guy-wire passed from the stern-reel to a wooden sheave held by a pulley block in the long beam that projected from the center of the platform outward between the bows of the catamaran. This beam was about 20 feet long, and was made adjustable, as its length depends on depth of immersion of the meter. Its length with reference to the hypotenuse and altitude of the triangle, of which it forms the base, must be such as will keep the suspending wire vertical. The guy-wire passes from the sheave to a small clamp that is attached to a cylinder of brass 1 inch long, which works up and down on the pipe of meter weight. This little cylinder has a clamp screw for adjusting it to the pipe at any desired height. The arrangements described above will without doubt keep apparatus perpendicular to the section. In this connection I would say that were it possible to use a rigidly fixed pipe for holding the meter it would, I think, be preferable. But we know on the Lower Mississippi at certain stages this would be impossible, on account of immense quantities of submerged drift that will be met with continually.

In *Annales des Ponts et Chaussées*, by M. De La Greve, a very good form of pipe attachment is described. I give a sketch of this in figure "B." It consists of a piece of gas-pipe of desired length with a small longitudinal section removed, as shown in the horizontal section, figure "*a*." The meter slides down this pipe and is kept from turning by the projection at *c*. Though the device is a good one, yet the guy plan, when worked carefully, is the more satisfactory and is always practicable. The battery connections were first made through the reels direct; but it was found advisable afterwards to use two small insulated wires for conducting the electric current. These wires served also as safety wires, as the suspending wire often broke. In such cases the conducting wires would hold the meter. The guy would prevent loss were these wires missing, but it would not prevent the injury that would be done by withdrawing it with the guy-wire. The battery connections were centralized in such manner that but two simple connections on the meter completed the circuit. The battery and register-cases were combined and attached by angle-wires to the catamaran in such manner as to prevent loss. The stern reel was graduated and connected with an index pointer in such manner that depths of less than one-tenth of a foot could be read off.

The meter weight consisted of a lead cylinder weighing about 60 pounds. The cylinder was about 10 inches long and about 4½ inches in diameter. A piece of ½-inch gas-pipe passed through the cylinder. This pipe was about 16 inches long. The meter was attached to this pipe. The top of the pipe terminated in a screw-tap containing the suspending wire clamp. A small brass cylinder containing the guy-wire clamp was attached to this pipe also.

The furniture of the catamaran consisted of a small skiff, a large sweep oar, a long pike pole, an ax, and set of signal flags. Life preservers for the party were also on board. This outfit, and careful training of the party, prevented losses or accidents of any kind during the year, which was one of the most trying ones that in all probability will ever be encountered by parties on work of this character.

The velocity work done with double floats, rod-floats, and the meter was refined in every detail possible, as the necessity of employing three methods made it absolutely necessary to secure as nearly perfect results as possible, in order to make a comparison of the methods, and to make the discharge work in general satisfactory. The reductions and the curves of velocity, area, and discharge deduced attest fully the accuracy of the work in detail.

The cause of not using the meter exclusively was due to the non-arrival of the launch and the loss of one of the connecting parts of the meter. Work with the meter was a perfect success from the start. After the equipment for making repairs was received from Saint Louis, not a single observation was taken by any other plan. Aside from this, I think the partial use of floats fortunate, as it will admit of a comparison of the methods and under favorable circumstances.

Besides the regular aerial work done by the party, an exhaustive examination of the grand cut-off near Black Hawk was made during the flood. No flow through the cut-off was manifest. In Red River, from the mouth of the bayou cut-off down to Spanish Fort, the current was very feeble during the flood. An examination was made of the Bayou des Glaises from the mouth to Hamburg, La. A discharge was also taken through a section about ½ mile above the mouth of this bayou.

The notes were kept written up daily. The calculations were kept up daily, and a discharge sheet transmitted weekly up to August 17, 1882. After that date no computation could be made, as my assistant, Mr. John C. Cammack, left the party, he having received official orders to report in Saint Louis.

A daily log was kept, also a daily summary. The latter book contained the gauge readings, temperatures of the air and water, direction and force of the wind, dates of rain, frosts, fogs, and other marked features of the weather; also a complete record of the kind and amount of work done daily, the condition of the data, &c.

When work on the river was impossible, the boat party were engaged in the shop, fabricating such articles as were required on the work, making repairs on the apparatus, &c.

The launch was kept in complete repair and improved considerably by the party. The stability of the launch and its excellent running power were fully established by the excellent condition it was in at the close of the work, after having been used severely for over a year. For work of this character launches of this type have no equal.

The results of the daily discharge observations are given so fully in the tables of calculations and curve charts appended to this report, that a discussion of them here is unnecessary.

The work was inspected by you in person on January 25 and 26, 1882, and again on November 23, 1882. The meter work in actual operation on the river, the plant, and all the auxiliary apparatus were inspected on November 23, 1882, by General H. G. Wright, Chief of Engineers, United States Army, General C. B. Comstock, president Mississippi River Commission, Maj. Amos Stickney, Maj. Chas. R. Suter, United States Army, Maj. B. M. Harrod, Prof. Henry Mitchell, and Judge R. C. Taylor.

The work of the party at Red River Landing closed on November 26, 1882, orders having been received on that date to close the work and proceed with party to the Bonnet Carré crevasse. The note-books and field supplies no longer required were transferred to the steamer Mississippi on November 26, 1882. All the calculations of discharge work for both the Mississippi and Atchafalaya; charts showing deduced curves of velocity, discharge, and area; a map showing relative position of cross-sections; a map of transverse velocity curves taken in bend; a map showing contour of river bed at all of the sections, are all appended to this report.

Before closing this part of my report I desire to acknowledge the valuable assistance rendered by my assistant, Mr. John C. Cammack; the cheerful, prompt, and accurate manner in which he performed his arduous duties during the most trying times of the great flood, and at all times while with my party, is worthy of praise which words are but meager to express.

The changes and action of the river in the vicinity of Red River Landing, and some facts regarding the flood height of 1882 and previous years, and other personal observations made during the year, will doubtless be of interest in connection with the above report.

The weather during the year was variable. It rained on 143 days; fogs prevailed periodically from January 5 to June 13. The minimum temperature of the air for the year was 38° (on January 30). The maximum temperature of the air was 98° (on August 17). The minimum temperature of the water was 44° (on January 30); the maximum temperature of the water was 84° (on June 30, July 1 to 6, August 17 to 31).

The temperatures of the water were taken at points of the section from bank to bank, and as near mid-depth as possible. These temperatures were valuable during the flood. The arrival of flood water from the Tensas region was shown by the temperatures of the Atchafalaya during the flood. On the day preceding the arrival on the Atchafalaya of the flood water referred to, the temperatures of the Mississippi and Atchafalaya were the same, which might be expected, as the Mississippi was discharging a portion of its waters into the Atchafalaya via Old River. On the day of the arrival of additional flood water on the Atchafalaya the temperature of the Atchafalaya was several degrees, thus indicating the source of the additional volume of water present in the river.

The river was rising on December 3, 1881, the day of the arrival of party at Red River Landing, and continued rising until December 6, when it began falling. It fell until December 27, on which date it began rising, and continued until March 27, 1882, on which date it reached its maximum stage not only for the year, but the highest ever known. The gauge at 12.30 o'clock on that day read 48.53 feet above the low-water mark of 1872, which is the zero of the gauge. This zero is 2.4 feet above sea level. This remarkable stage of the river was 1.53 feet above high-water mark of 1874, and 2.26 feet above high-water mark of 1867. The high-water marks of the years 1867,

1874, and 1882 are 46.27, 47.05, and 48.53 respectively. It will be seen from these figures that the flood intervals from 1867 to 1882 are 7 and 8 years, respectively; the rise of the flood surface for these periods, 0.78 and 1.48 feet.

The general character of the Old River water-way, and the effects of the periodic flow inward and outward, will doubtless be of interest here. The period of change of flow is generally 3 days. The first sign manifest is a marked checking of the current in Old River, and a more marked degree of clearness in the water. These changes are very easily noticed on the first day. On the second day the current nearly ceases. On the third, the change of flow is found to have taken place; the current will be found as swift as usual, and the water will have the usual mud color. The direction of flow is, of course, governed by the relative stages of the Mississippi and the Atchafalaya, the Red River, of course, governing the Atchafalaya. The current is swifter when the flow is outward. The general effects of an inward flow are more injurious to the Old River water-way than an outward flow is, and for this reason, that when the flow is inward, the current is greatly diminished and the percentage of sediment in the water is visibly greater.

These two ruling elements, which under the circumstances act in unison, cause a more rapid fill, while the checking of the current diminishes the scouring that characterizes an outward flow.

Turnbull Island is also an obstacle to the flow through Old River, and at flood stages it forms the basis of marked fills all the way around the island. It is in fact the nucleus of all the sand-bars in the vicinity. The effects of an outward flow are more beneficial to navigation than an inward flow, though at certain points, which will be described presently, it has a damaging effect. It is in general more beneficial, as the current is more rapid, and the percentage of sediment in the water is much smaller, as Red River water has, I think, a smaller percentage of sediment than Mississippi water. The deep-red color of the former is due to matter held in solution rather than that held in suspension. These are the things which make an outward flow favorable to navigation. The shoal places in Old River are three in number, and are situated as follows: At Barbre's crossing, in vicinity of Ash Cabin Bend, and at the Mississippi mouth of Old River. The causes that have produced this shoaling I consider to have been as follows: At the Barbre crossing the shoaling is due to the checking of the current of Red River as it sweeps around the bend where it enters Old River. In turning this bend, it loses a great part of its velocity, which it cannot possibly recover until it gets some distance beyond Barbre's crossing. The effect of this is the piling up of the sediment which the river has pushed to this point, and which the loss of velocity prevents from being carried farther. The deposit from the water itself is also augmented, owing to the slackening up of the current. The flow either way from Old River causes a fill at this crossing, and for this reason, that when the flow is outward the current is checked in the Red River bend as before; when the flow is inward the current is checked near the turn at the Ash Cabin; and when it gets to Barbre's crossing, it encounters Red River, which is moving nearly at right angles to it. So it is seen both streams meet at this point in a somewhat exhausted condition. Their forces are so nearly equal that equilibrium is nearly produced, which action, as is obvious, causes the fill or shoaling referred to.

The equalization of the forces of the water at this point is verified by the well-defined color line that is always seen at this point. The shoaling near the Ash Cabin is due to the decrease of velocity caused by Old River encountering the bends it meets before it reaches this point. The fill is greater at this point when the current is inward, as the arm of the bend with reference to an inward flow is more abrupt. The shoaling at the mouth is due wholly to an inward flow. The large volume of Mississippi water that sweeps around the turn at Carr's Point carries with it a vast volume of sediment, which it leaves at the shoal section referred to for want of sufficient velocity to carry it farther. The loss of velocity in this case is much greater than in any of the others mentioned; the fill is in consequence much greater. The steamboat channel at entrance of Old River attests the great force and action of the water as it sweeps around this point. This channel, just before you enter Old River, is nearly at right angles to the Old River Channel. On both sides of it, immense sand reefs exist. This channel resembles a canal more than it does a natural passage.

This channel is due to the action of the maximum thread of the current, which sweeps around the point at the mouth with a tremendous force and passes the mouth without entering. It is this portion of the current that produces the channel at the entrance of Old River. This point of Old River is benefited materially by an outward flow, as the volume of water coming out scours more rapidly. The outward volume pushes the Mississippi water as it rounds Carr's Point farther toward the left bank; *i. e.*, it has that tendency. This action causes the bar at the point of Old River (the nucleus of which is Carr's Point) to make rapidly down stream. Its make is due wholly to the meeting of the two rivers at this point when the flow is outward. By meeting they lose a large percentage of their velocity, and thus increase the sedimentary deposit at this point. This bar made about 300 feet down stream last year.

Should the flow continue outward from Old River without changing, and low stages of the river predominate for any great length of time, this bar would eventually work its way down stream and connect with the main bank of the Mississippi below Tor-nola, and thus close up Old River at low water entirely. This section of the country, and more especially that within a radius of 10 miles from the center of Turnbull's Island, is a very interesting one, and is a wide field for investigation at the present time, as it no doubt contains the unknown quantities that make the problem of the change of the Mississippi channel at the present time a vague uncertainty.

Respectfully submitted.

JOHN EWENS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge observations, Red River Landing, La.

In this tabulation the gauge readings, water area, maximum depth, width, mean velocity, discharge, direction and force of wind, temperature of air and water, and finished were copied from note-books Nos. 831–835, 839–844, 854.

Rise or fall between any two days was obtained by taking the difference between the gauge readings on those days.

Scour or fill between any two days was obtained thus: Take the difference between the water area on the first day, counted for rise or fall for the time considered, and the water area of the second day. If the area of the second day is the larger, the difference is scour; and if the smaller, this difference is fill.

Datum was taken at a gauge reading of 48.5 feet, and surface width of 3,918 feet, on March 27.

Datum area is the water area of March 27 and = 234,480 square feet.

Subsequent datum areas were obtained by successively adding and subtracting the scours and fills.

Datum areas between December 14 and March 27, 1882, were obtained by working backward from March 27.

Mean depth was obtained by dividing the water area by the water width.

Mean datum depth was obtained by dividing datum area by datum width.

Discharge observations at Red River Landing, La.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Dimensions of cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1881.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	[illegible]		°	°		
Dec. 14	30.29		149,960	219,147	40.02	55.93	58.0	3,747		4.417	[illegible]	[illegible] 5	50		D. F.	M=Meter. R=Rod floats. D. F=Double floats.
15	29.66	−0.63														
16	28.79	−0.87	147,120	221,919	39.38	56.64	59.2	3,736	+ 2,772	4.370	[illegible]	[illegible] 2	44		D. F.	
17	27.85	−0.94	141,840	220,147	38.05	56.19	56.0	3,728	− 1,772	4.207	[illegible]	[illegible] 5	47		D. F.	
18	26.91	−0.94														
19	25.95	−0.96	133,120	218,487	35.94	55.76	57.0	3,704	− 1,660	4.257	[illegible]	[illegible]	50		D. F.	
20	24.97	−0.98														
21	24.17	−0.80														
22	23.55	−0.62	123,680	217,921	33.51	55.6?	53.1	3,691	− 506	3.961	[illegible]	[illegible]	45		D. F.	
23	23.15	−0.40														
24	22.95	−0.20	119,520	215,973	32.47	55.12	58.0	3,681	− 1,948	4.082	[illegible]	[illegible]	47		D. F.	
25	23.11	+0.16														
26	23.67	+0.56														
27	24.61	+0.94	125,760	216,089	34.02	55.15	55.3	3,697	+ 116	4.148	521,674	XI 3	55		R.	
28	25.72	+1.11														
29	26.80	+1.08														
30	27.98	+1.18	141,840	219,648	37.99	53.06	56.7	3,734	+ 3,559	4.514	640,327	V 4	46		D. F.	
31	29.00	+1.02	146,240	220,241	39.20	56.21	56.1	3,731	+ 593	4.302	629,164	III 4	48		D. F.	
1882.																
Jan. 1	30.16	+1.16														
2	30.84	+0.68														
3	31.59	+0.75	159,600	223,914	42.57	57.15	62.1	3,749	+ 3,673	4.519	720,892	XII 4	52		D. F.	
4	32.19	+0.60														
5	32.69	+0.50	160,720	220,906	42.78	56.38	59.0	3,757	− 3,008	4.661	749,035	XII 2	68		D. F.	
6	33.02	+0.33														
7	33.50	+0.48														
8	34.17	+0.67														
9	34.58	+0.41														
10	34.78	+0.20														
11	35.11	+0.33														
12	35.28	+0.17														
13	35.50	+0.22														
14	35.69	+0.19														
15	35.87	+0.18														

	18	36.40	+0.[illegible]	178,760	221,[illegible]					− 170	8.449	997,715	VI	3	39	......	D.F.	
	19	36.65	+0.16	176,080	220,2[illegible]					− 844			VI	3	45	......	D.F.	
	20	36.96	+0.31	177,791	210,578				3,762	− 657	8.906	1,080,094	VI	3	50	......	D.F.	
	21	37.59	+0.63															
	22	37.73	+0.14	170,480	217,214			[illegible]0	3,735	− 2,361	5.725	1,010,411	XII	4	44	......	D.F.	
	23	37.87	+0.14	170,760	210,368	47.[illegible]	[illegible]	66.4	3,771	− 2,104	5.590	1,004,878	IX	4	63	......	D.F.	
	24	38.17	+0.30															
	25	38.39	+0.22	182,720	220,708	48.62	56.33	67.7	3,758	+ 1,340	5.509	1,006,013	XII	4	70	......	D.F.	
	26	38.60	+0.21															
	27	38.87	+0.27	188,080	224,186	49.88	57.22	67.5	3,771	+ 3,478	5.711	1,074,031	VIII	4	63	......	D.F.	
	28	39.10	+0.23															
	29	39.47	+0.37															
	30	39.65	+0.18															
	31	39.84	+0.19															
Feb.	1	39.94	+0.10															
	2	39.98	+0.04	191,440	224,228	50.79	57.23	70.0	3,769	+ 42	5.691	1,089,579	VIII	3	51	44	D.F.	
	3	40.23	+0.25															
	4	40.49	+0.26	195,014	225,879	51.67	57.65	69.0	3,774	+1,651	6.094	1,188,491	VI	4	51	45	D.F.	
	5	40.66	+0.17															
	6	40.81	+0.15	190,480	220,137	50.41	56.19	70.0	3,779	−5,742	6.128	1,167,260	XI	3	54	46	D.F.	
	7	40.91	+0.10	195,476	224,755	51.64	57.36	60.0	3,785	+4,618	6.224	1,216,624	X	3	59	47	D.F.	
	8	41.12	+0.21	193,040	221,525	51.11	56.54	68.0	3,777	−3,230	6.262	1,208,903	I	5	63	48	D.F.	
	9	41.27	+0.15	196,820	224,238	51.92	57.28	69.0	3,781	+2,718	5.361	1,052,566	V	4	54	48	M.	
	10	41.49	+0.22	192,160	219,247	50.88	55.96	69.0	3,777	−4,901	5.721	1,009,393	XI	3	53	50	M.D.F.	
	11	41.60	+0.11	191,280	220,951	51.36	56.39	70.0	3,783	+1,704	5.610	1,089,972	XI	4	61	51	D.F.	
	12	41.71	+0.11															
	13	41.89	+0.18															
	14	42.07	+0.18	196,400	221,292	51.85	56.48	71.0	3,788	+ 341	5.925	1,162,751	XII	2	55	54	D.F.	
	15	42.24	+0.17	197,120	221,369	52.15	56.50	70.5	3,780	+ 77	5.895	1,162,059	XII	3	63	54	D.F.	
	16	42.35	+0.11															
	17	42.53	+0.18	200,880	224,032	53.02	57.18	71.4	3,785	+2,603	5.885	1,182,091	V	3	71	56	D.F.	
	18	42.65	+0.12	204,080	226,778	53.90	57.88	71.8	3,786	+2,746	5.747	1,172,742	XI	5	70	56	D.F.R.	
	19	42.80	+0.15															
	20	42.96	+0.16															
	21	43.19	+0.23	207,200	227,853	54.68	58.16	73.0	3,789	+1,075	5.856	1,213,404	VI	5	51	58	D.F.	
	22	43.30	+0.11	209,840	230,076	55.35	58.72	72.5	3,791	+2,223	5.704	1,196,874	VI	4	50	58	D.F.	
	23	43.42	+0.12	209,920	229,701	55.34	58.63	73.4	3,793	− 375	5.845	1,227,062	V	4	50	58	D.F.	
	24	43.61	+0.19	209,360	228,417	54.65	58.30	71.5	3,831	−1,284	5.768	1,207,497	VII	3	57	58	D.F.	
	25	43.80	+0.19															
	26	43.95	+0.15															
	27	44.14	+0.19	214,000	231,021	55.54	58.96	72.0	3,853	+2,604	5.738	1,227,923	XI	30-3	65	58	D.F.	
	28	44.33	+0.19	217,320	233,609	56.40	59.02	72.0	3,853	+2,588	5.691	1,236,683	I	30-3	67	58	D.F.	
Mar.	1	44.62	+0.29	213,920	229,091	55.40	58.47	72.0	3,857	−4,518			VII	3	62	58	M.	Incomplete data.
	2	44.82	+0.20	218,880	233,274	55.99	59.54	73.5	3,909	+4,183	5.629	1,232,031	XI	2	60	59	M.	
	3	45.09	+0.27	219,210	232,580	56.23	59.36	74.0	3,899	− 694	5.086	1,246,667	XI	2	66	60	M.	
	4	45.30	+0.21															
	5	45.48	+0.18															
	6	45.76	+0.28															
	7	45.95	+0.19	228,440	238,420	58.36	60.85	76.5	3,914	+5,840	5.824	1,330,327	VII	5	60	62	D.F.	
	8	46.24	+0.29	229,600	238,445	58.66	60.86	76.0	3,914	+ 25	5.814	1,334,914	I	5	61	62	D.F.	

MISSISSIPPI RIVER.—*Discharge observations at Red River Landing, La.*—Continued.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Dimensions of cross-section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq.*		*C*		°	°		
Mar. 9	46.52	+0.28	230,080	237,829	58.78	60.70	75.3	3,914	−			3	60	62	D. F.	
10	46.78	+0.26	230,160	236,891	58.80	60.46	76.8	3,914	−			4	57	62	D. F.	
11	46.87	+0.09	231,040	237,419	59.18	60.60	77.2	3,904	+				62	62	D. F.	
12	47.03	+0.16														
13	47.24	+0.21	233,240	238,175	59.74	60.79	77.5	3,904	+				67	61	D. F.	
14	47.30	+0.06	233,280	237,981	59.75	60.74	78.5	3,904	−				72	63	D. F.	
15	47.38	+0.08	233,600	237,988	59.62	60.74	78.5	3,918	+				75	66	D. F.	
16	47.50	+0.12	237,600	241,518	60.64	61.64	79.0	3,918	+3,				79	67	D. F.	
17	47.56	+0.06	237,760	241,443	60.68	61.62	79.0	3,918	−				79	67	D. F.	
18	47.63	+0.07	234,080	237,489	59.74	60.61	79.0	3,918	−3,954				74	67	D. F.	
19	47.70	+0.07														
20	47.77	+0.07	234,560	237,420	59.87	60.60	79.0	3,918	− 69	[illegible]	[illegible]	I 4	74	68	D. F.	
21	47.98	+0.21														
22	48.02	+0.04														
23	48.12	+0.10	231,760	233,249	59.15	59.53	77.0	3,918	−4,171	6.087	1,410,753	V 4	66	70	D. F.	
24	48.25	+0.13	234,320	235,300	59.81	60.06	78.0	3,918	+2,051	6.290	1,473,808	VI 4	68	70	D. F.	
25	48.30	+0.05	231,040	231,824	58.97	59.17	77.5	3,918	−3,476	6.360	1,469,116	XII 4	65	67	D. F.	
26	48.46	+0.16														
27	48.50	+0.04	234,480	234,480	59.85	59.85	79.0	3,918	+2,656	6.222	1,458,902	V 2	74	76	D. F.	
28	48.43	−0.07	237,520	237,794	60.92	60.69	80.5	3,899	+3,314	6.458	1,533,950	VII 2	62	64	D. F.	
29	48.39	−0.04	237,360	237,790	60.88	60.69	80.2	3,899	− 4	6.484	1,539,145	VI 4	65	62	D. F.	
30	48.36	−0.03	234,160	234,707	60.06	59.77	80.0	3,899	−3,083	6.427	1,504,922	VI 1	74	66	D. F.	
31	48.32	−0.04	235,360	236,063	60.36	60.07	80.5	3,899	+1,356	6.778	1,595,310	VII 1	74	66	D. F.	
Apr. 1	48.25	−0.07														
2	48.23	−0.02														
3	48.09	−0.14	236,240	237,840	60.59	60.70	78.0	3,899	+1,777	6.448	1,523,193	0 0	74	66	D. F.	
4	47.95	−0.14	235,440	237,586	60.38	60.64	77.0	3,899	− 254	6.063	1,427,409	X 30–2	67	66	D. F.	
5	47.83	−0.12	233,680	236,294	59.93	60.31	77.0	3,899	−1,292	6.061	1,416,342	X 30–2	69	66	D. F.	
6	47.70	−0.13	234,400	237,521	60.12	60.62	77.5	3,899	+1,227	6.336	1,485,310	X 30–1	70	66	D. F.	
7	47.56	−0.14	233,440	237,107	59.87	60.52	79.0	3,899	− 414	6.256	1,460,453	X 30–2	70	66	D. F.	
8	47.39	−0.17	236,240	240,570	60.59	61.40	78.5	3,899	+3,463	5.978	1,412,243	X 4	72	67	D. F.	
9	47.23	−0.16														
10	47.03	−0.20	237,120	242,850	61.18	61.98	79.5	3,876	+2,280	6.012	1,425,566	0 0	73	67	D. F.	

	22	45.77	−0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						D.F.
	23	45.69	−0.08													
	24	45.61	−0.08	247,520	258,752	63.94	66.04	78.7	3,871	− 261	5.515	1,305,451	X	2	73	66	D.F.
	25	45.52	−0.09	231,360	262,940	64.93	67.11	79.5	3,871	+4,188	5.206	1,308,545	X	2	71	66	D.F.
	26	45.35	−0.17	250,160	262,398	64.62	66.97	78.6	3,871	− 542	5.266	1,317,874	XI	2	70	67	D.F.
	27	45.28	−0.07	246,000	258,509	63.55	65.98	79.4	3,871	−3,889	5.353	1,316,928	XI	30–1	73	67	D.F.
	28	45.12	−0.16	245,440	258,568	63.40	65.99	79.3	3,871	+ 59	5.356	1,314,596	X	1	70	68	D.F.
	29	45.00	−0.12	244,560	258,153	63.18	65.89	78.7	3,871	− 415	5.171	1,304,554	VII	30–5	75	67	D.F.
	30	44.85	−0.15													
May	1	44.71	−0.14	239,600	254,816	61.90	64.91	79.0	3,871	−3,837	5.203	1,246,719	XII	2	67	67	M.&D.F.
	2	44.59	−0.12	239,200	254,381	61.79	64.63	79.0	3,871	+ 65	5.121	1,235,013	XII	1	68	69	D.F.
	3	44.34	−0.25	237,600	253,749	61.88	64.76	79.0	3,871	− 632	5.082	1,207,592	II	30–2	73	69	D.F.
	4	44.24	−0.10	238,720	255,256	61.67	65.15	77.0	3,871	+1,507	5.402	1,289,490	II	1	76	65	D.F.
	5	44.09	−0.15	238,400	255,517	61.59	65.22	77.2	3,871	+ 261	5.161	1,280,809	XI	2	74	67½	D.F.
	6	43.95	−0.14	238,160	255,819	61.52	65.29	78.0	3,871	+ 302	5.217	1,242,592	VII	5	76	65½	D.F.
	7	43.77	−0.18													
	8	43.88	+0.11	238,240	256,170	61.54	65.38	78.0	3,871	+ 351	5.045	1,201,889	XII	6	74	66	D.F.
	9	43.64	−0.24													
	10	43.59	−0.05	237,360	256,413	61.32	65.44	77.5	3,871	+ 243	4.908	1,163,865	XII	4	73½	65	D.F.
	11	43.28	−0.31	236,480	256,718	62.66	65.52	76.3	3,774	+ 305	4.843	1,145,338	IV	3	69	67	D.F.
	12	43.07	−0.21	235,600	256,630	62.56	65.50	76.8	3,766	− 88	5.312	1,251,457	IV	2	68	67	M.
	13	42.92	−0.15	234,240	255,835	62.20	65.30	76.3	3,766	− 795	4.969	1,163,882	IV	5	66	67	M.
	14	42.78	−0.14													
	15	42.64	−0.14	236,480	259,129	62.84	66.14	77.5	3,763	+3,294	5.157	1,219,465	VI	2	65	66	M.
	16	42.49	−0.15	235,760	258,973	62.65	66.10	78.0	3,763	− 156	5.008	1,180,768	VII	1	74	67	M.
	17	42.37	−0.12	235,600	259,264	62.64	66.17	77.0	3,761	+ 291	5.059	1,191,831	VII	1	66	69	M.
	18	42.25	−0.12	236,560	260,675	62.90	66.53	76.5	3,761	+1,411	5.117	1,210,498	XI	2	73	65	M.
	19	42.10	−0.15	235,480	260,159	62.59	66.40	77.0	3,762	− 516	5.114	1,204,132	XI	5	72	65	M.
	20	41.91	−0.19	234,240	259,634	62.26	66.27	76.7	3,762	− 525	5.018	1,175,841	XI	4	70	65	M.
	21	41.92	+0.01													
	22	41.86	−0.06	233,040	258,622	61.95	66.01	75.7	3,762	−1,012	4.778	1,113,540	VI	3	66	65	D.F.
	23	41.77	−0.09	232,160	258,081	61.73	65.87	75.4	3,761	− 541	5.014	1,164,070	VII	30–4	67	68	M.
	24	41.61	−0.16	231,600	258,123	61.61	65.88	75.0	3,759	+ 42	4.950	1,146,364	XI	3	71	65	M.
	25	41.50	−0.11	231,280	258,216	61.53	65.91	75.2	3,759	+ 93	4.939	1,142,104	VIII	3	75	66	M.
	26	41.43	−0.07	229,120	256,319	60.95	65.42	75.8	3,759	−1,897	4.984	1,142,017	XI	3	77	67	M.
	27	41.38	−0.05	230,800	258,187	61.42	65.90	75.0	3,758	+1,868	5.004	1,155,019	XII	3	71	69	M.
	28	41.36	−0.02													
	29	41.34	−0.02	229,360	256,897	61.02	65.57	75.2	3,759	−1,290	4.937	1,132,356	VIII	1	76	68	M.
	30	41.31	−0.03													
	31	41.42	+0.11	231,360	258,596	61.55	66.00	75.2	3,759	+1,699	4.918	1,137,809	XI	5	69	67	M.
June	1	41.44	+0.02	232,240	259,401	61.78	66.21	76.0	3,759	+ 805	4.900	1,138,053	VI	4	75	68	M.
	2	41.45	+0.01	233,760	260,883	62.19	66.59	76.1	3,759	+1,482	4.998	1,168,341	X	30–2	75	69	M.
	3	41.41	−0.04	233,120	260,393	62.02	66.46	75.5	3,759	− 490	4.827	1,125,864	I	30–2	79	71	M.
	4	41.40	+0.01													
	5	41.42	+0.02	232,240	259,475	61.68	66.23	76.0	3,765	− 918	4.725	1,097,308	VIII	30–4	75	69	M.

[illegible] Discharge observations at Red River Landing, La.—Continued.

Date										Mean velocity.	Discharge per [illegible]	Direction and force of wind.		Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66.91	[illegible]	3,769	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66.76	75.8	3,769	[illegible]	[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66.32	75.7	3,769	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	
[illegible]	[illegible]	[illegible]															
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61.94	66.25	76.0	3,771	[illegible]	[illegible]	[illegible]	[illegible]					
[illegible]	41.[illegible]	0.06	[illegible]1,460	260,203	62.11	66.41	76.0	3,774	[illegible] 040	4.088	[illegible]	XII	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	41.[illegible]	0.00	234,240	260,043	62.67	66.37	74.0	3,774	100	4.771	1,11[illegible]	XII	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	41.[illegible]	0.01															
[illegible]	41.[illegible]	0.01	234,600	259,879	61.94	66.[illegible]	[illegible]	3,778	164	4.800	1,123,131	XI	2	[illegible]	[illegible]	[illegible]	
24	41.[illegible]	0.01	234,080	259,997	61.95	66.36	74.0	3,778	[illegible] 118	4.683	1,090,201	X	3	67	81	M	
25	41.77	0.00															
26	41.75	−0.02	235,200	261,193	62.26	66.67	73.4	3,778	+1,106	4.673	1,090,150	I	30–2	88	81	M	
27	41.70	−0.05															
28	41.68	−0.02	235,360	261,617	62.31	66.77	74.2	3,777	+ 424	4.612	1,085,367	X	30–2	80	83	M	
29	41.59	−0.09															
30	41.56	−0.03	234,080	260,790	61.99	66.56	75.0	3,770	− 827	4.727	1,106,412	I	30–2	90	84	M.	
July 1	41.48	−0.08	232,800	259,812	61.65	66.31	75.0	3,770	− 078	4.670	1,089,329	I	30–3	90	81	M.	
2	41.42	−0.06															
3	41.38	−0.04	232,000	259,390	61.49	66.20	74.0	3,777	422	4.578	1,062,127	IV	3	91	84	M.	
4	41.30	−0.08	232,560	260,[illegible]	61.57	66.42	74.2	3,777	+ 862	4.572	1,063,144	IV	3	87	84	M.	
5	41.28	−0.02	233,520	261,268	61.83	66.69	73.0	3,777	1,036	4.573	1,067,802	VII	45–7	78	84	M.	
6	41.19	−0.09															
7	41.11	−0.08	233,200	261,610	61.74	66.77	73.0	3,777	+ 822	4.545	1,059,954	X	30–2	85	83	M.	
8	41.05	−0.06	231,040	259,677	61.17	66.28	74.0	3,777	−1,988	4.518	1,043,857	XI	4	78	80	M.	
9	41.00	−0.05															
10	40.95	−0.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Date		Gage height	Change
	14		−0.04
	15	40.97	−0.02
	16	40.97	−0.08
	17	40.81	−0.10
	18	40.44	−0.06
	19	40.45	−0.07
	20	40.38	+0.01
	21	40.28	−0.07
	22	40.21	−0.10
	23	40.19	−0.07
	24	40.19	−0.02
	25	39.96	0.00
	26	39.83	−0.20
	27	39.67	−0.17
	28	39.54	−0.15
	29	39.33	−0.13
	30	39.03	−0.21
	31	38.71	−0.30
Aug.	1	38.32	−0.32
	2	37.89	−0.39
	3	37.47	−0.43
	4	36.72	−0.42
	5	35.88	−0.75
	6	35.24	−0.84
	7	33.99	−0.64
	8	32.85	−1.25
	9	32.10	−1.14
	10	30.85	0.75
	11	30.07	1.25
	12	28.78	0.78
	13	28.20	−1.29
	14	27.58	0.58
	15	27.30	0.62
	16	26.95	0.28
	17	26.60	0.35
	18	26.22	0.35
	19	25.90	0.38
	20	25.77	0.32
	21	25.20	0.13
	22	24.62	0.52
	23	23.90	0.63
	24	23.37	0.63
	25	22.70	0.67
	26	22.12	0.67
	27	21.60	0.58
	28	21.28	0.47
	29	20.80	0.37
	30	20.37	0.48
	31	19.60	0.53
Sept.	1	19.04	0.62
			0.61

233,080	263,375	61.89	67.22	75.0	8,776	+ 791	4.403	1,028,803	V	8-08	83	81	M.
234,160	263,931	62.01	67.36	74.4	8,776	+ 556	4.402	1,014,845	V	8-08	85	81	M.
231,760	261,839	61.38	66.83	75.0	8,776	−2,098	4.494	1,047,420	I	8-08	81	81	M.
230,800	261,477	61.14	66.74	74.0	8,775	− 358	4.504	1,039,434	X	80-8	81	81	M.
231,280	262,183	61.40	66.92	75.0	8,767	+ 706	4.418	1,021,870	I	80-8	83	80	M.
230,640	261,807	61.24	66.82	74.6	8,766	− 376	4.370	1,007,047	X	80-8	79	80	M.
231,520	263,064	61.49	67.14	74.5	8,765	+1,257	4.446	1,029,268	X	80-8	83	81	M.
231,040	262,848	61.37	67.09	74.5	8,765	− 216	4.376	1,010,961	VII	80-8	80	81	M.
231,020	262,903	61.36	67.10	75.0	8,765	+ 55	4.352	1,005,309	VII	80-8	82	81	M.
228,000	261,275	60.69	66.69	74.0	8,757	−1,628	4.209	959,559	VII	80-8	79	81	M.
224,640	258,967	59.81	66.10	72.2	8,756	2,308	4.183	939,664	V	[illegible]	[illegible]	81	M.
224,160	259,276	59.66	66.18	72.4	8,757	+ 309	4.115	922,525	XII	[illegible]	[illegible]	81	M.
220,960	258,405	58.81	65.95	73.0	8,757	871	4.104	906,705	VII	[illegible]	[illegible]	81	M.
219,040	257,950	58.32	65.84	73.0	8,756	455	4.065	890,473	V	[illegible]	[illegible]	81	M.
216,800	257,325	57.72	65.68	73.0	8,756	625	[illegible]	[illegible]	I	[illegible]	[illegible]	81	M.
211,680	256,508	56.40	65.49	70.5	8,750	797	[illegible]	808,900	XI	[illegible]	[illegible]	[illegible]	M.
209,440	257,510	[illegible]	65.72	71.4	8,751	[illegible]	[illegible]	771,493	X	[illegible]	[illegible]	[illegible]	M.
202,240	257,305	[illegible]	65.70	68.0	8,748	115	[illegible]	[illegible]	III	[illegible]	[illegible]	[illegible]	M.
199,300	258,763	[illegible]	66.05	[illegible]	8,749	[illegible]	[illegible]	[illegible]	IV	[illegible]	[illegible]	[illegible]	M.
196,040	257,545	[illegible]	65.70	68.0	8,740	[illegible]	[illegible]	[illegible]	IV	[illegible]	[illegible]	[illegible]	M.
189,040	257,290	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	II	[illegible]	[illegible]	[illegible]	M.
178,550	257,603	47.07	65.76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
177,500	257,050	47.00	65.76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
174,100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
172,450	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	254,434	44.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	43.14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
140,010	254,101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M.

MISSISSIPPI RIVER.—*Discharge observations at Red River Landing, La.*—Continued.

Date.	Gauge. Reading.	Gauge. Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr. Air.	Temperature, Fahr. Water.	Method.	Remarks.
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic* [illegible]		°	°		
Sept. 2	18.35	−0.69	140,273	253,565	38.08	64.72	47.5	3,684	− 757	2.615	39[illegible]	VI 4	82	83	M.	
3	17.73	−0.62														
4	17.18	−0.55	136,310	253,909	37.06	64.81	45.8	3,678	+ [illegible]	[illegible]	[illegible]	[illegible]		84	M.	
5	16.17	−1.01	134,362	255,675	36.55	65.26	46.0	3,676	+1[illegible]	[illegible]	[illegible]	[illegible]	86	84	M.	
6	16.11	−0.06														
7	15.56	−0.55	129,173	252,726	35.22	64.50	45.0	3,668	−2,[illegible]	[illegible]	[illegible]	[illegible]	87	83	M.	
8	15.32	−0.24	128,207	252,642	34.95	64.48	44.6	3,668	− [illegible]	[illegible]	[illegible]	[illegible]	76	83	M.	
9	15.00	−0.32														
10	14.84	−0.16														
11	14.50	−0.34	123,973	251,409	33.90	64.17	43.5	3,657	− [illegible]	[illegible]	[illegible]	[illegible]	79	81	M.	
12	14.23	−0.27	122,186	250,609	33.42	63.96	43.0	3,656	− [illegible]	[illegible]	[illegible]	[illegible]	70	80	M.	
13	14.04	−0.19	121,761	250,879	33.30	64.03	42.6	3,657	+ [illegible]	[illegible]	[illegible]	[illegible] 3	94	81	M.	
14	13.98	−0.06														
15	13.98	0.00	122,029	251,366	33.37	64.16	42.7	3,657	+ 487	2.448	298,784	X 3	83	79	M.	
16	14.00	+0.02	121,112	250,376	33.12	63.90	43.0	3,657	− 990	2.502	303,034	VII 3	90	79	M.	
17	13.92	−0.08														
18	13.83	−0.09	119,949	249,834	32.08	63.77	42.6	3,653	− 542	2.462	295,414	XII 4	84	80	M.	
19	13.71	−0.12	120,274	250,597	32.96	63.96	41.9	3,649	+ 763	2.464	296,393	X 3	87	80	M.	
20	13.51	−0.20	119,587	250,640	32.75	63.97	42.3	3,651	+ 43	2.504	299,503	X 4	85	80	M.	
21	13.34	−0.17														
22	13.02	−0.32														
23	12.70	−0.32	114,874	248,882	31.51	63.52	42.0	3,646	−1,758	2.456	282,135	VII 5	68	78	M.	
24	12.62	−0.08														
25	12.82	+0.20	115,298	248,869	31.63	63.52	42.0	3,645	− 13	2.468	284,667	VIII 4	77	77	M.	
26	13.20	+0.38	117,335	249,521	32.18	63.69	42.0	3,646	+ 652	2.514	295,596	VII 4	76	76	M.	
27	13.70	+0.50														
28	14.11	+0.41	122,169	251,032	33.40	64.07	43.0	3,658	+1,511	2.609	318,800	XII 6	76	76	M.	
29	14.38	+0.27														
30	14.41	+0.03	122,236	250,001	33.40	63.81	43.8	3,660	−1,031	2.456	300,314	XI 3-6	79	77	M.	
Oct. 1	14.33	−0.08														
2	13.90	−0.43														
3	13.43	−0.47	119,537	250,884	32.74	64.03	43.8	3,651	+ 883	2.392	287,934	VII 3	80	76	M.	
4	12.86	−0.57	117,550	250,978	32.21	64.06	42.0	3,650	+ 94	2.320	272,665	{VII} [illegible] 4	78	76	M.	

	13	9.46	+0.02	104,924	250,765	28.90	64.00	39.0	3,631	− 949	2.141	224,679	{VI}			
	14	9.43	−0.02	103,975	249,889	28.59	63.78	39.0	3,637	− 876	2.228	231,735	VIII	4	74	75	M.
	15	9.39	−0.04														
	16	9.24	−0.15	101,910	248,515	28.04	63.43	38.0	3,635	−1,374	2.196	223,833	XI	4	70	75	M.
	17	9.18	−0.06	102,035	248,858	28.07	63.52	38.0	3,635	+ 343	2.296	234,282	VIII	4	77	74	M.
	18	9.20	+0.02														
	19	9.20	+0.00														
	20	9.30	+0.10														
	21	9.35	+0.15	101,573	247,778	27.94	63.24	39.5	3,635	−1,080	2.225	225,988	VI	4	63	72	M.
	22	9.47	+0.12														
	23	9.58	+0.11	103,586	248,955	28.50	63.54	39.8	3,635	+1,177	2.396	248,240	VI	4	67	71	M.
	24	9.73	+0.15														
	25	9.94	+0.21	110,662	254,722	30.42	65.01	42.6	3,638	+5,767	2.370	262,355	XI	4	69	70	M.
	26	10.19	+0.25	102,799	245,949	28.25	62.77	39.4	3,639	−8,773	2.442	251,097	XI	2–5	74	70	M.
	27	10.45	+0.26	101,837	244,040	27.96	62.29	40.4	3,642	−1,909	2.472	251,842	XI	3	71	70	M.
	28	10.53	+0.08	104,300	246,212	28.64	62.84	40.7	3,642	+2,172	2.442	254,697	I	3	73	70	M.
	29	10.55	+0.02														
	30	10.47	−0.08	103,087	245,217	28.31	62.56	40.2	3,641	− 995	2.423	250,705	XI	4	......	69	M.
	31	10.41	−0.06														
Nov.	1	10.35	−0.06	103,436	246,003	28.42	62.79	40.3	3,640	+ 786	2.530	261,766	I	2	78	70	M.
	2	10.16	−0.19														
	3	9.94	−0.22	101,312	245,371	27.83	62.63	40.0	3,640	− 632	2.408	244,024	VII	5	70	69	M.
	4	9.79	−0.15	98,674	243,279	27.11	62.09	39.8	3,640	−2,092	2.447	241,534	VII	2	66	69	M.
	5	9.70	−0.09														
	6	9.68	−0.02	99,211	244,216	27.29	62.33	38.0	3,635	+ 937	2.425	240,685	I	3–5	69	69	M.
	7	9.66	−0.02	99,887	244,965	27.48	62.52	39.0	3,635	+ 749	2.416	241,363	XII	3	70	68	M.
	8	9.66	0.00	101,824	246,902	28.01	63.02	40.5	3,635	+1,937	2.462	250,940	XII	3	71	69	M.
	9	9.66	0.00														
	10	9.70	+0.04	102,050	246,983	28.07	63.04	41.0	3,635	+ 81	2.502	255,374	XII	4	69	68	M.
	11	9.82	+0.12	101,700	246,197	27.96	62.84	41.0	3,637	− 786	2.381	242,166	I	5	74	68	M.
	12	10.07	+0.25														
	13	10.23	+0.16														
	14	10.33	+0.10	105,549	248,189	28.96	63.35	40.5	3,645	+1,992	2.470	260,753	VII	5	44	65	M.
	15	10.40	+0.07	104,962	247,347	28.80	63.13	40.0	3,645	− 842	2.448	256,945	VII	3	45	65	M.
	16	10.49	+0.09														
	17	10.74	+0.25	104,637	245,782	28.67	62.73	41.5	3,650	−1,565	2.567	268,626	VII	5	60	63	M.
	18	10.93	+0.19														
	19	11.31	+0.38														
	20	11.83	+0.52	108,299	245,464	29.65	62.65	41.2	3,653	− 318	2.652	287,295	V	6	44	63	M.
	21	12.20	+0.37	111,261	247,074	30.46	63.06	42.4	3,653	+1,610	2.628	292,445	VIII	4	41	62	M.
	22	12.60	+0.40	112,324	246,675	30.71	62.96	42.0	3,658	− 399	2.718	305,339	XI	4	51	66	M.
	23	12.93	+0.33	112,949	246,092	30.85	62.81	43.0	3,661	− 583	2.757	301,652	XII	4	60	67	M.

Discharge observations, Atchafalaya River.

u tions for the discharge of the Atchafalaya River were made in the l n :

re obtained by plotting the sections on cross-section paper, locat the position of velocity observations, then dividing the section into partial areas, counting the small squares in each area; thus giving to each velocity an area, un two or more velocities were taken very close together, in which case an area given to the mean of this group of velocities.

The sum of these partial areas being the total area of section.

The discharge for partial areas was obtained by multiplying the area by its veloc

The total discharge being the sum of the partial discharges thus obtained.

The mean velocity was obtained by dividing the total discharge by the total ar

The mean depth is obtained by dividing the area by the water width.

The maximum depth is the deepest actual sounding taken.

Scour or fill is the difference in sectional area obtained by actual area differe compared with difference due to change of gauge; 51 feet was taken as datum gau reading, being .13 foot above highest gauge-reading when observations were tak the difference in area due to this difference in gauge was added to the water are March 28; the area tl as the datum area.

The other datum successively adding or subtracting scours and fills.

Mean datum depth wa ng the datum area by the datum wid 1,030 feet.

Owing to the record he note-books being very unsatisfact they were discarded interpolated from the Barbres Land gauge in the followin

The gauge is at t ya, about 1,500 feet above the discha section. A curve v er from this gauge, and readings w interpolated for 4 p. time is the mean time of daily obser tions.

The differen ge at section and Barbres gauge was termined plied to readings on Barbres gauge.

The com ade in the field; after that date in office.

A discharge curve was al of the observations farthest from line were recomputed; in error, others checking closely.

A. H. WEBE

Discharge observations at Atchafalaya River.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.												
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							Air.	Water.		
1881.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*O'clock.*	*Force.*	°	°		
Dec. 12	31.20																
13	30.90	—0.30	24,860	41,915	33.6	40.7	68.0	739.7		4.060	101,145.6	III	4			D. F.	Double floats.
14	30.45	—0.45															
15	20.90	—0.55	22,500	40,293	30.6	39.1	64.0	735.1	—1,622	3.592	80,832.8	IX	5			D. F.	
16	29.13	—0.77															
17	28.35	—0.78															
18	27.30	—1.05															
19	26.40	—0.90															
20	25.50	—0.90															
21	24.73	—0.77	18,660	39,885	31.4	38.7	60.1	592.7	— 408	3.263	60,890.7					D. F.	
22	24.14	—0.59															
23	23.80	—0.34	18,320	40,093	31.2	38.9	60.0	586.4	+ 208	2.843	52,100.0	V	3			D. F.	
24	23.72	—0.08															
25	23.90	+0.18															
26	24.32	+0.42	18,520	39,984	30.6	38.8	59.6	604.6	— 109	3.118	57,752.6	XII	4			D. F.	
27	25.17	+0.85															
28	26.30	+1.13	19,320	39,566	30.8	38.4	62.0	625.4	— 418	3.435	66,377.4	XI	3			D. F.	
29	27.27	+0.97	19,080	38,714	30.0	38.5	64.1	635.7	— 852	3.372	64,354.8	V	5			D. F.	
30	28.10	+0.83															
31	29.05	+0.95															
1882.																	
Jan. 1	29.85	+0.80															
2	30.60	+0.75															
3	31.40	+0.80															
4	31.95	+0.55	25,140	41,539	33.6	40.3	69.0	746.1	+2,825	4.036	101,477.2					D. F.	
5	32.40	+0.45															
6	32.85	+0.45	25,160	40,885	33.4	39.7	67.0	751.3	— 654	3.553	89,402.0					D. F.	Rain-fog-drift. Observation doubtful.
7	33.35	+0.50															
8	33.92	+0.57															
9	34.35	+0.43															
10	34.75	+0.40	26,680	40,932	33.8	39.7	64.0	799.8	+ 47	4.172	111,316.4	XII	5			D. F.	
11	35.10	+0.35															
12	35.22	+0.12	27,380	41,253	33.5	40.0	67.0	815.1	+ 321	4.246	116,241.7	XII	3			D. F.	and logs. Observation taken with difficulty.
13	35.60	+0.38															
14	35.95	+0.35															
15	36.20	+0.25															

Discharge observations at Atchafalaya River—**Continued.**

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cubic feet.	O'clock. Force.	°	°		
Jan. 16	36.45	+0.25														
17	36.80	+0.35														
18	37.02	+0.22														
19	37.23	+0.21														
20	37.65	+0.42														
21	38.04	+0.39														
22	38.30	+0.26														
23	38.60	+0.30														
24	39.00	+0.40														
25	39.23	+0.23														
26	39.45	+0.22														
27	39.75	+0.30														
28	40.00	+0.25														
29	40.27	+0.27														
30	40.60	+0.33														
31	40.83	+0.23														
Feb. 1	40.95	+0.12														
2	41.13	+0.18														
3	41.25	+0.12														
4	41.43	+0.18														
5	41.60	+0.17														
6	41.85	+0.25														
7	42.05	+0.20														
8	42.30	+0.25														
9	42.60	+0.30														
10	42.83	+0.23														
11	42.93	+0.10														
12	43.05	+0.12														
13	43.25	+0.20														
14	43.45	+0.20														
15	43.65	+0.20														
16	43.92	+0.27														
17	44.30	+0.38														
18	44.53	+0.23														
19	44.65	+0.12														
20	44.90	+0.25														

	21	45.18	+0.[illegible]	[illegible]	[illegible]	41.2	[illegible]	[illegible]	[illegible]	—1,[illegible]	[illegible]	[illegible]	V	5			D.F.
	22	45.40	+0.[illegible]														
	23	45.68	+0.28														
	24	45.73	+0.10														
	25	45.90	+0.17														
	26	46.20	+0.30														
	27	46.45	+0.25														
	28	46.75	+0.30														
Mar.	1	46.95	+0.20														
	2	47.20	+0.25														
	3	47.45	+0.25														
	4	47.70	+0.25														
	5	47.95	+0.25														
	6	48.15	+0.20	37,500	40,480	*36.7	39.3	85.0	1,022.0	+ 794	4.825	180,949.2	VII	5			D.F.
	7	48.20	+0.05	40,340	43,267	38.4	42.0	85.5	1,049.9	+2,787	5.022	202,575.5	VII	5			D.F.
	8	48.70	+0.50														
	9	48.95	+0.25														
	10	49.15	+0.20	30,340	41,270	37.4	40.0	87.5	1,049.9	—1,907	5.088	200,180.5	VII	4			D.F.
	11	49.35	+0.20														
	12	49.53	+0.18														
	13	49.63	+0.10	40,200	41,684	38.0	40.4	89.0	1,058.6	+ 414	5.981	240,814.3	V	3			D.F.
	14	49.73	+0.10	30,880	41,198	37.6	40.0	90.0	1,058.7	— 486	5.733	228,620.6	XI	4			D.F.
	15	49.83	+0.10	41,000	42,212	38.6	40.9	90.0	1,058.7	+1,014	5.617	230,313.2	VII	3			D.F.
	16	49.93	+0.10	39,840	40,946	37.6	39.5	90.3	1,058.7	—1,266	5.970	237,841.0	X	3			D.F.
	17	50.03	+0.10	40,480	41,481	38.5	40.2	87.0	1,050.0	+ 535	5.711	231,516.1	X	3			D.F.
	18	50.10	+0.07	40,080	41,008	38.5	39.8	90.0	1,040.0	— 473	5.603	224,555.1	II	4			D.F.
	19	50.10	0.00														
	20	50.15	+0.05														
	21	50.33	+0.18														
	22	50.43	+0.10	39,400	39,987	38.2	38.8	87.0	1,030.0	—1,021	5.486	216,161.8					D.F.
	23	50.53	+0.10	38,160	38,644	37.0	37.5	86.0	1,030.0	—1,343	6.192	236,286.6	II	4			D.F.
	24	50.63	+0.10	38,380	38,761	37.2	37.6	90.0	1,030.0	+ 117	5.446	209,008.7	III	4			D.F.
	25	50.73	+0.12														
	26	50.85	+0.12														
	27	50.97	+0.12														
	28	50.87	—0.10	38,150	38,284	37.9	37.1	90.0	1,030.0	— 477	6.921	264,050.0	XII½	3	62	67	D.F.
	29	50.80	—0.07	38,940	39,146	38.3	38.0	89.0	1,030.0	+ 862	7.047	274,408.0	VII	1	76	67	D.F.
	30	50.80	0.00	39,160	39,366	38.0	38.2	88.0	1,030.0	+ 220	6.907	270,480.0			79	67	D.F.
	31	50.77	—0.03	38,500	38,737	37.3	37.6	88.0	1,030.0	— 629	7.288	280,613.4	0	0	74	65	D.F.
Apr.	1	50.67	—0.10	38,080	38,420	36.9	37.3	86.0	1,030.0	—317	6.304	240,040.8	0	0	76	66	D.F.
	2	50.57	—0.10														
	3	50.47	—0.10	38,120	38,666	37.0	37.5	88.0	1,030.0	+246	5.007	190,858.2			74	65	D.F.
	4	50.37	—0.10	38,060	38,709	36.9	37.5	88.5	1,030.0	+ 43	6.497	247,290.9			71	66	D.F.
	5	50.27	—0.10														
	6	50.07	—0.20	37,900	38,858	36.7	37.7	84.5	1,030.0	+149	5.505	208,673.5			73	66	D.F.
	7	50.00	—0.07	38,480	39,510	37.3	38.3	88.5	1,030.0	+652	5.430	208,934.6			72	66	D.F.
	8	49.97	—0.03														
	9	49.83	— 0.14														
	10	49.67	—0.16	38,680	40,249	37.5	38.8	86.5	1,029.5	+539	5.575	215,643.3			77	68	D.F.
	11	49.57	—0.10	38,500	39,972	37.3	38.8	88.0	1,029.5	— 77	5.112	196,811.8			76	68	D.F.
	12	49.47	—0.10	38,060	39,635	37.0	38.5	89.0	1,027.0	—337	5.238	199,359.5			76	68½	D.F.
	13	49.37	—0.10														

* Decrease of mean depth is owing to ledge 200 feet wide becoming submerged by slight rise, increasing water width.

	15	[illegible]	[illegible]														
	16	43.70	+0.07														
	17	43.70	+0.00														
	18	43.70	−0.00														
	19	43.67	−0.03														
	20	43.60	−0.07														
	21	43.60	0.00														
	22	43.60	0.00	33,060	39,714	41.7	38.5	82.8	792.8	−380	5.405	178,075.9	VI	1	[illegible]		
	23	43.60	0.00														
	24	43.57	−0.03														
	25	43.50	−0.07														
	26	43.47	−0.03														
	27	43.40	−0.07														
	28	43.37	−0.03														
	29	43.30	−0.07	33,380	40,271	42.1	39.0	80.0	791.7	+557	5.505	183,760.2	XI	2	95	84	M.
	30	43.27	−0.03														
July	1	43.17	−0.10														
	2	43.07	−0.10														
	3	42.97	−0.10														
	4	42.87	−0.10														
	5	42.77	−0.10														
	6	42.70	−0.07	32,460	39,825	42.2	38.7	80.2	788.8	[illegible] 446	5.602	181,851.2	V	1	89	84	M.
	7	42.68	−0.02														
	8	42.57	−0.11														
	9	42.47	−0.10														
	10	42.40	−0.07														

Discharge observations at Atchafalaya River—Continued.

Date.	Gauge.	Change.	Area of cross-section.	[illegible]	Mean [illegible]	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind. O'clock.	Force.	Temperature Fahr. Air.	Temperature Fahr. Water.	Method.	Remarks.
1887.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cubic feet.			°	°		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	769.8	+ 380	5.201	169,434.6	XI½	3	92	83	M.	
[illegible]	[illegible]	[illegible]	[illegible]	40,961	41.7	39.1	82.8	797.5	+ 156	5.252	169,443.9	X	2	86	81	M.	
26	41.07	−0.10															
27	40.93	−0.14	31,440	40,210	42.1	39.6	70.8	794.5	− 151	5.269	165,666.0	V	3	89	80	M.	
28	40.73	−0.20															
29	40.53	−0.20															
30	40.30	−0.23															
31	40.00	−0.30															
Aug. 1	39.70	−0.30															
2	39.35	−0.35															
3	38.90	−0.45	29,820	40,196	37.8	39.0	79.0	787.5	− 14	4.591	136,901.5	XI	1	86	81	M.	
4	38.40	−0.50															
5	37.60	−0.80															
6	36.82	−0.78															
7	36.00	−0.82															
8	35.10	−0.90															
9	34.20	−0.90															
10	33.30	−0.90															
11	32.40	−0.90	24,900	40,320	32.4	39.1	71.0	766.4	+ 124	4.169	104,417.2	XI	1	81	81	M.	
12	31.55	−0.85															
13	30.67	−0.88															

	20	26.75	−0.75														
	21	26.10	−0.65														
	22	25.47	−0.63	18,560	39,728	30.0	38.5	65.0	650.9	− 55	3.647	71,847.8	VI	3	90	84	M.
	23	24.68	−0.79														
	24	24.00	−0.68														
	25	23.50	−0.50														
	26	22.90	−0.60														
	27	22.40	−0.50														
	28	21.90	−0.50														
	29	21.40	−0.50														
	30	21.17	−0.23	17,580	40,368	29.6	39.5	60.0	591.4	+ 640	2.755	48,296.9	XII	3	98	84	M.
	31	21.03	−0.14														
Sept.	1	20.90	−0.13														
	2	20.30	−0.60														
	3	19.40	−0.90														
	4	18.90	−0.50														
	5	18.42	−0.48														
	6	17.70	−0.72	14,640	39,509	25.2	38.3	55.6	579.2	− 859	2.318	33,870.5	IV	4	119	84(?)	M.
	7	17.18	−0.53														
	8	16.73	−0.45														
	9	16.46	−0.27														
	10	16.10	−0.36														
	11	15.80	−0.30														
	12	15.50	−0.30														
	13	15.23	−0.27														
	14	15.10	−0.13	13,080	39,396	22.7	38.2	53.0	572.5	− 113	2.370	30,892.8	VI	4	78	82	M.
	15	15.07	−0.03														
	16	14.97	−0.10														
	17	14.90	−0.07														
	18	14.80	−0.10														
	19	14.57	−0.23														
	20	14.40	−0.17														
	21	14.13	−0.27	12,500	39,419	21.9	38.2	51.6	569.3	+ 23	2.300	28,761.4	VI	4	76		M.
	22	13.85	−0.28														
	23	13.53	−0.32														
	24	13.40	−0.13														
	25	13.40	0.00														
	26	13.43	+0.03														
	27	13.76	+0.33	12,210	39,339	21.5	38.1	49.5	567.5	− 80	2.353	28,738.2	I	3	68	76	M.
	28	14.25	+0.49														
	29	14.60	+0.35														
	30	14.57	−0.03														
Oct.	1	14.40	−0.17														
	2	14.05	−0.35	12,400	39,363	21.6	38.1	52.0	572.3	+ 24	2.326	28,844.6	V	4	77	77	M.
	3	13.65	−0.40														
	4	13.20	−0.45														
	5	12.65	−0.55														
	6	12.27	−0.38														

Discharge observations at Atchafalaya River—Continued.

Date.	Gauge.		Dimensions of cross section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Read.	Rise or fall in 24 h.	Area.	Below [illegible]	Depth. Mean.	Mean [illegible]	Maximum.							Air.	Water.		
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Feet.	Cubic feet.	O'clock.	Force.	°	°		
1887. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	XI½	3	93	85	M.	
[illegible]	[illegible]	[illegible]	16,440	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	9,950	39,327	17.5	38.1	47.1	561.5	— 305	1.998	19,882.6	VI	[illegible]	[illegible]	[illegible]	[illegible]	
24	11.90	+0.38	10,650	38,828	18.8	37.7	49.0	565.1	— 499	2.417	25,748.5	XI	3	83	70	M.	
25	12.25	+0.35															
26	12.60	+0.35															
27	12.90	+0.30															
28	13.13	+0.23															
29	13.20	+0.07															
30	13.17	—0.03															
31	13.10	—0.07															
Nov. 1	13.07	—0.03															
2	12.93	—0.14	12,390	39,987	21.9	38.8	51.4	503.4	+1,159	2.343	29,038.0	V	3	78	70	M.	
3	12.77	—0.16															
4	12.67	—0.10															
5	12.60	—0.07															
6	12.60	0.00															
7	12.60	0.00															
8	12.60	0.00															
9	12.63	+0.03	11,770	39,536	20.9	38.4	49.5	562.1	— 451	2.282	26,858.7	VII	3	70	71	M.	
10	12.73	+0.10															
11	12.83	+0.10															
12	12.97	+0.14															

,930	60,300	11.1	14.1	[illegible]	[illegible]

6.—At Winona, Minn., John Ewens, Assistant in Charge.

(Note.—Results in Report of Commission for 1882, page 127.)

Office Mississippi River Commission,
Saint Louis, Mo., June 1, 188[illegible]

Sir: I have the honor to inform you that in accordance with your instructio[illegible] received in September, 1880, I proceeded to Wabasha, Minn., where I comple[illegible] organization of party and made immediate preparations to carry out your instructio[illegible]

After a careful examination of the topography of the country in the vicinity [illegible] Wabasha, I found that a formidable outlet known as "Beef Slough," situated so[illegible] distance back from the left bank, would make the locality a very undesirable one [illegible] the work of gauging, which first of all for its success requires the absence of outle[illegible] Surveys and sectional soundings of the river at this point were sent to Saint Lo[illegible] for examination. In a very brief time afterward orders were received for the par[illegible] to remove to Winona, 47 miles below. Examinations similar to those made at W[illegible]basha were made at Winona, and at the town of Homer, about 4 miles below. [illegible] large number of sections were sounded at both of the places mentioned, and a se[illegible]tion for discharge measurement selected at both. The Winona section was situat[illegible] about 1½ miles below the Chicago and Northwestern Railroad bridge. This sectio[illegible] was selected on account of the banks being higher than elsewhere in the vicinit[illegible] and owing to the absence of eddies and other disturbing elements that detract fro[illegible] the accuracy of discharge work. The Winona section, though the best to be foun[illegible] in the vicinity, presented many disadvantages which no doubt have their influence o[illegible] work of this character, where refinement is so desirable. The most prominent draw[illegible]back was the presence of large numbers of immense rafts which skirted the righ[illegible] bank for miles above and below the discharge section, extending for some distanc[illegible] out in the river. The effect of such obstructions on the velocity and change[illegible] of bed is so obvious that a description here of their effect is unnecessary. In conse[illegible]quence of the constant presence of these rafts I thought for a time that the Home[illegible] section would be preferable, but found that at high water the discharge would be par[illegible]tial on account of a small outlet fed by the river above this section. So, in view of all these facts, Winona was finally decided on.

On account of the absence of supplies, work with the electric plant designed by you could not be commenced until the spring of 1881. Rod-floats were employed for velocity measurements until the closing of the river, which took place on November 29, 1880. After the closing of the river preparations were begun immediately for the winter work through the ice with the water-meter. The severity of the winter in this State suggested to me the propriety of devising some plan by which the work could be continued without interruption from the cold. To meet this difficulty, a sled-house was designed and constructed. It consisted of an oblong structure, large [illegible] the members of the party to conduct the work in. This house was [illegible] which were clad with steel; a window on the front [illegible] the light required. A trap-door with a portable [illegible] of the house for lowering and raising the meter. The [illegible] of a desk for recording and holding the register, a stove, [illegible] for lowering and raising the meter and inte[illegible] [illegible] was as follows: The stations having been previousl[illegible] [illegible] in the ice at each station, the center of the hole bein[illegible] [illegible] of the station-[illegible]. A path, the center of which was the sectio[illegible] [illegible] to the gauge of the runners of the sled, was then cu[illegible] [illegible] With these arrangements to perform the work, it was simply nece[illegible] [illegible] the house over the opening, raise the trap-door, and insert the trap-ca[illegible] [illegible] meter for the observations. The trap-casing proved to be an e[illegible] [illegible] It excluded the air completely, and formed a woode[illegible] [illegible] the house. [illegible] in the ice. To illustrate how admirably the house pla[illegible] [illegible] state that the party continued the work successfull[illegible] [illegible] a perfect gale, and the thermometer indicated [illegible] the temperature within the house w[illegible] [illegible]

[illegible] was conducted with all the care and refineme[illegible] [illegible] beneath the surface no doubt detract[illegible] [illegible] Were it not for this fact, the work wou[illegible] [illegible] as the manner of working and a[illegible] [illegible] This work was continued until the brea[illegible] [illegible] of April 4, 1881. Though the riv[illegible] [illegible] the party had made arrangements d[illegible] [illegible] to begin discharge work wi[illegible] [illegible] of April 5, six hours after t[illegible] [illegible] anchorage used, and the gene[illegible] [illegible]

of plant and method of working, have been described so fully by you in the ress report of the Commission for 1881, that a description here is unnecessary. open-river work was continued successfully until October 23, 1881, orders hav- been received to leave Winona with the party on October 25, 1881. In connection the regular discharge work, the following work was done: slope observations taken daily, sediment and dredge specimens were taken at regular periods, and itudinal soundings were taken as often as time would permit. The dredge-work made of more than passing interest on account of the refinements introduced in ging. The system of sieves used enabled the party to do this work perfectly. work was inspected by you in person on July 15, 1881. The computed discharges other calculations, with maps of reach, chart showing deduced curves of dis- ge, velocity, and areas; also sketches showing portable sled-house and dredge; photograph of electric plant in actual working position, are all appended to this rt. The discharge data, with map of reach and curve chart, appeared in the ress report of the Commission for 1881. The necessity of beginning the work on Lower Mississippi as soon as possible after closing the work at Winona prevented report from accompanying the data mentioned at that time.

conclusion, I desire to acknowledge the valuable assistance rendered by my rder, Mr. Hiram Phillips, who performed all his duties in a manner worthy of the est commendation I can give him.

Very respectfully, your obedient servant,

JOHN EWENS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

7.—AT HANNIBAL, MO., HOMER P. RITTER, ASSISTANT, IN CHARGE.

(NOTE.—Results in Report of Commission for 1882, page 138.)

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., October 8, 1883.

SIR: I have the honor to submit herewith a report on the observations of the gaug- party stationed at Hannibal, Mo., from October, 1880, to October, 1881.

In accordance with instructions received from you, I left Saint Louis October 9, 1880, and proceeded to the mouth of the Des Moines River to make a reconnaissance a favorable location for obtaining the discharge of the Mississippi River below the mouth of the Des Moines River.

I arrived at Warsaw, Ill., October 11, and proceeded at once to make a reconnais- sance of the river in this vicinity. On October 15 I received your communication in- forming me that the Commission had examined the following location, *i. e.*, 500 feet above the Hannibal bridge and connecting with the Suy Levee, and found it well adapted for a gauging station, and that it should be occupied unless a decidedly bet- ter one be discovered.

I started immediatly for Hannibal, Mo., and after examining the location indicated, decided to locate there, finding it well adapted for gauging purposes.

A preliminary survey of the locality was then made; the discharge section estab- lished; range polls and targets erected; slope gauges established and put up; the necessary plant collected; the wire anchorage laid and the electrical float apparatus put together. Everything being ready, observations were commenced November 12, 1880, and continued until October 24, 1881, when orders were received to discontinue the observations. The party consisted of one recorder and two boatmen, with an additional boatman during high water.

Location of the section.—The section was located 500 feet above the Hannibal bridge and parallel to the same. The Mississippi River at this point is very narrow, being only 1,200 feet wide at low water; 1,500 feet at a bank-full stage, and 2,550 feet at ex- treme high water, 1,000 feet of the latter width being the distance from the left bank to the Suy Levee, this distance being covered only a few feet in depth during high water. On the right bank the bluffs run close to the river. The deepest water in the section was about 30 feet, at low water, distant about 400 feet from the right bank. The bottom of the river was uniform, sloping from each bank towards the deepest part. The path of the current was normal to section.

Nature of the observations.—The observations made during the season consisted of: (1) A measurement of the river's discharge, taken every available day. (2) Slope of the river surface for a distance of 2,000 feet above and 2,000 feet below the dis- charge-section. (3) Sediment samples of the water taken at different points in the section at various stages, to determine the amount of sediment carried in suspension.

(4) Dredging, obtaining specimens of the bottom of the river, to determine material and changes in material. (5) Tri-daily readings of the water-gauge.

Discharge.—Discharge observations with the rod-float plant were commenced November 11, and were continued November 12, 13, and 15. These observations had to be discontinued, with the exception of December 13 and 14, on account of running ice, until the river froze over, which occurred on December 29. From January 3 to March 10, inclusive, discharge observations were taken by cutting holes in the ice and using a current-meter. After the ice had broken up and ceased running (April 7), the wire anchorage was again put in, and the discharge observations with rod-float plant resumed, and continued to October 12, when observations at the station were discontinued. During the season 94 discharges were obtained, 29 of which were meter discharges. The discharge observations were reduced and computed during the season, and the results forwarded to the office at Saint Louis, Mo. Taking a discharge consisted in obtaining a cross-section of the river by means of soundings, and determining the velocity of the current at various points in the section. The soundings were taken either with a pole or a lead-line, and were 25 feet apart. A 20-pound lead was used. Velocities were taken every 100 feet by means of rod-floats or current-meter.

In determining velocities by means of rod-floats 6 rods were run to each station, and a mean taken for the observed velocity at that point. When the current-meter was used a mid-depth and an integrated velocity were taken at each station.

In reducing and computing rod discharges, the observed velocities of the rods were reduced to the mean velocity in the vertical section by Francis' formula, *i. e.*:

$$v'=v\left(1-0.116\left[\sqrt{\frac{D-D'}{D}}-0.1\right]\right)$$

in which

v' = mean velocity.

v = observed velocity.

D = depth of water.

D' = immersion of rod.

The cross-section was divided into partial areas by ordinates midway between the observing stations. The mean of the result of rods run at any station was multiplied into the corresponding partial area, and the partial discharges thus obtained were added together for the total discharge. The latter quantity was divided by the total cross-section for the mean velocity of the river. The meter discharges were computed in the same manner, with the exception that a mean of the mid-depth and integrated velocity at each station was multiplied into its corresponding partial cross-section.

In taking discharges with rod floats, the following plant was used, the principal features being the wire anchorage, the electrical float apparatus, and the rod floats.

The wire anchorage consisted of a No. 9 steel wire running across the river and fastened at each shore. From this cross-wire anchor wires ran up stream every 100 feet. The anchor wires were 200 feet long, one end being fastened to the cross-wire and the other to a large stone weighing from two to three hundred pounds. When not in use, this wire system lay at the bottom of the river.

The electrical-float apparatus used was rigged in the following manner: Across the stern of a 22 foot skiff is bolted an outrigger 20 feet long and five inches wide, which is graduated to feet. From the extremities of this outrigger two wires, each 100 feet long, supported on battens, trail down stream, and to their lower ends is attached another similar strip supported on three buoys; the upper and lower strips, together with the two side wires, forming a parallelogram 20 by 100 feet. On the up-stream face of the lower outrigger is fastened a strip of sheet copper one inch wide extending the whole length of the board. In front of the above copper strip is stretched a similar copper band, supported at each end on wooden bridges.

The strip of copper which is fastened to the face of the lower outrigger is connected with an insulated wire running along one of the wires forming the parallelogram, and the copper band in front of the strip is connected with a similar insulated wire running along the other wire of the parallelogram. The two insulated wires lead into the upper skiff, where they are connected with a battery and electric bell. At the middle of the lower outrigger is attached a skiff used in catching the floats. The rods used were cylindrical in shape, 1¼ inches in diameter and from 3 to 25 feet in length. To the bottom of the rods were attached tin cans of the same diameter as the rods and from 12 to 30 inches long. These cans were filled with shot, thus enabling the rods to float in an upright position. A discharge with the float apparatus was taken in the following manner: The apparatus having been gotten ready, the shore-end of the cross-wire was raised and put over the bow of the upper skiff, where

(4) Dredging, obtaining specimens of the [illegible] points in the section were taken,
and changes in material. (5) Tri-daily rea[illegible] through holes cut in the i
Discharge.—Discharge observations with [illegible] October 14, the dredging was
vember 11, and were continued November [illegible] an iron frame, to which a
be discontinued, with the exception of Dec[illegible]
until the river froze over, which occurred [illegible] mentioned above, were the sa
10, inclusive, discharge observations were [illegible]
a current-meter. After the ice had brok[illegible] by each dredging was kept, d
anchorage was again put in, and the dis[illegible]
sumed, and continued to October 12, wh[illegible] labeled, were forwarded to S
tinued. During the season 94 discharge[illegible] and the results, in tabular f
charges. The discharge observations w[illegible] through holes in the ice the follow
and the results forwarded to the office a[illegible] It consisted of a cylind
sisted in obtaining a cross-section of th[illegible] open at one end and closed a
ing the velocity of the current at vario[illegible] was riveted to the outside (len
taken either with a pole or a lead-line, [illegible] inches beyond the open end
used. Velocities were taken every 10[illegible] gas-pipe. The rod was compos
In determining velocities by means o[illegible] for screwing together, thereby
a mean taken for the observed veloci[illegible] the depth required.
used a mid-depth and an integrated [illegible] at an angle of about 130°, a
In reducing and computing rod dis[illegible] scooping up the material. The dr
reduced to the mean velocity in the [illegible] stream. In pulling it up to the sur
[illegible] thereby enabling the material fro
[illegible] any change by having the smaller
in which $v'=v($ [illegible] work without fail every time and a

$v'=$ [illegible]

$v=$ [illegible]

$D=$ [illegible]

$D'=$ [illegible]

HOMER P. RITTER,
Assistant Engin

The cross-section was divided i[illegible]
observing stations. The mean o[illegible]
into the corresponding partial [illegible]
added together for the total dis[illegible] E. DAVIS, ASSISTANT IN CHARGE.
cross-section for the mean vel[illegible]
puted in the same manner, with [illegible] Commission for 1882, page 142.)
tegrated velocity at each station[illegible]
section.

[illegible] MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 13, 18

In taking discharges with ro[illegible]
features being the wire anchor[illegible] following report, on the observations at G
The wire anchorage consist[illegible] 1880, to October 25, 1881.
fastened at each shore. From[illegible] by the assistant about the middle of Octo
feet. The anchor wires were [illegible] at hand, so that little more than loca
and the other to a large ston[illegible] Upon the arrival of two boatmen, a recon
not in use, this wire system [illegible] the river was made, for the purpose of loca
The electrical-float appara[illegible] of C. L. Harrison, recorder, the party was
stern of a 22 foot skiff is hol[illegible] and two boatmen. There was a good de
is graduated to feet. From [illegible] putting up gauges, constructing plant, puttin
feet long, supported on batt[illegible] putting up signals. Owing to the fact tha
another similar strip suppo[illegible] the material and tools were delayed, much
with the two side wires, fo[illegible] work. Most of it had to be done with borro
face of the lower outrigger [illegible] November, the preparations had advanced
the whole length of the bo[illegible] the method of plant set forth in the instructio
the copper band, support[illegible]
The strip of copper wh[illegible]
[illegible] with an insulated[illegible]
[illegible] the copper ba[illegible]
[illegible] along the[illegible]
[illegible] the upper skiff[illegible]
[illegible] of the bo[illegible]
[illegible]

...ENT.

...ly, when practicable. [illegible] ...ed. They were [illegible]

....	[illegible]
....	[illegible]
....	[illegible]
....	[illegible]
....	[illegible]
....	[illegible]
....	[illegible]

...very irregular in the early part of the season. ...s stopped running on account of ice, and did not ...eriod there was no way of forwarding specimens. ...e boats commenced running again, sediment was ...until August, when it was taken weekly. Several ...the shipping-boxes not being promptly returned. ...s were taken and forwarded to the office. ...thly, after and including March. The [illegible] ...till late in December, and it was impossible to obtain ...January and February. Ten sets of specimens were ...e.

...made daily when more important work did not occupy ...r of the observations were rendered worthless by the ...e a level was obtained with which to connect them. ...observations were made. ...vations were made with the meter during the ice period. ...ary 119 curves were determined at 13 different stations

...s already stated, the first discharge was taken on Novem... ...on the 16th, both being by the plant method. On the [illegible] ...menced to flow in large quantities, and from that date till ...clear of it.

...ning ice the river blocked, but did not freeze over. For ...immense fields of ice that covered more than half the river ...h to work upon. This continued through December, during ...ssible to measure discharges. As soon as the river became ...ter was brought into immediate use. The ice remained until ... and the meter was employed up to that time; there were a ...repairs needed on the instrument. Although the ice began to ...ork upon it early in February, it did not break away till the ...eanwhile no discharges could be measured. As soon as the ice ...discharges were taken by timing ice chunks, a few floats being ...ould be handled. The distances were all estimated by guess. ...l running, the use of double floats was continued until a new ...at in and arrangements made for using the plant; during March ...six sets of observations were made in this way. On the 5th of ...ge was completed and the original method by plant resumed. By ...er was becoming very high. After five sets of observations were ...nt the anchorage was swept away by the swelling volume of water. ...were made to replace it. Several wires were stretched across the ...broken before being used; some of the breaks were occasioned by ...them near shore. Finally, upon witnessing the wire break in mid- ...e force of the current alone, all efforts to keep it in were abandoned. ...t request a transit was furnished the party, and on April 16 the first ...tions was made with double floats located from shore. This method ...ill the middle of July, ninety-one discharges having been taken in this

...middle of July, free rods were substituted for double floats, the river then ...ough to handle them conveniently. This was not practicable in high ...a skiff party of only two boatmen, who had to manage the skiff, handle ...ake and record the soundings. Free rods were used and located with ...il August, 25 discharges being taken. On the 19th of August the plant ...as resu[illegible] the river having become sufficiently low to make it practicable. ...e now [illegible] xclusively. This method was kept up till the 4th of October, ...ght dis[illegible] s having been taken. By the 1st of October the river had again

, 24 to October 14 nine different points in the section w being added on the Illinois side of the river.

ry 5 to March 7, the dredgings were made through holes described below. From March 24 to October 14, the dr skiff, by means of a canvas bag surrounding an iron frame, ttached.

stations used, with the addition of the two mentioned above, previous dredgings.

A specimen of the bottom of the river obtained by each dredgin and analyzed.

The specimens, 324 in number, put in tin boxes and labeled, were Louis, Mo. The specimens were analyzed in the field, and the resu comprising 39 sheets, forwarded. When dredging through holes in th described dredge was found to answer the purpose. It consist sheet-iron 18 inches long and 6 inches in diameter, open at one other. A strip of wrought iron 1 by ¼ by 20 inches was riveted t wise) of the cylinder, and allowed to project a few inches beyon this strip was screwed a rod made of half-inch gas-pipe. The sections, each 7 feet long, with gas-pipe couplings for screwing mitting the rod to be lengthened or shortened, as the depth req

The section nearest the cylinder was bent upwards at an ang ing the cylinder to be pulled along the bottom, scooping up the was let into the water-cylinder—end down stream. In pullin the cylinder assumed a perpendicular position, thereby enabli bottom to be brought up without undergoing any change by ticles washed out. The dredge was found to work without f depths in the section.

Very respectfully, your obedient servant,

Ho

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

8.—AT GRAFTON, ILL., J. H. DAVIS, ASSIST

(NOTE.—Results in Report of Commission for

OFFICE MISSISSIP
Sc

SIR: I have the honor to submit the following repo ton, Illinois, made from October 15, 1880, to October

The scene of operations was reached by the assistan There was neither material nor assistance at hand, s could be done during the first week. Upon the arriv sance of the most favorable portion of the river was a gauging section. Upon the arrival of C. L. Harris plete, consisting of assistant, recorder, and two bo preliminary work to be done in putting up gauges anchorage, laying off ranges and putting up sign instruments were furnished, and the material an was lost unnecessarily in this work. Most of i utensils. Finally, on the 13th of November, th ciently to measure a discharge by the method of p

The serial work consisted of—

1st. Discharge observations.
2d. Sediment observations.
3d. Dredging observations.
4th. Slope observations.
5th. Determining vertical velocity curves.

[illegible]

... ing, and
... [illegible]
... rifted as
... [illegible]
... ed to the
... ups.
... [illegible]
... For the
... e of 2,000 feet
... half tenths of
... ly. In
... led about 2 feet
... in the bottom
... gage while being
..., each one having
the middle gauge.
... as rapidly
... ty were reaching ...
... t had ... would
... Unfortunately
... f being ... till
... ions to March ... were
... on the Illinois shore.
17. A great number of
down. When a new ...
In this way a continuous
until a head was ...
of the gauge rods were
logs. For this reason ...
all cases. The ... for the
... not large enough to ...

meter, during the ... season,
... cities were obtained by taking
the surface to the bottom. The
... of the ice. The lowest point
... as lowered as in the discharge
... [illegible]

be done except to attend to the slope g[illegible] ant and recorder was occupied in co[illegible] In this way much time was saved i[illegible] season. Mr. C. L. Harrison, recorder, [illegible] leave of absence, extending from the [illegible] charge of the observations, and execu[illegible] sistant labored under great disadvant[illegible] was frequently impracticable to carry [illegible] was pursued that seemed, in the jud[illegible] cumstances.

Respectfully submitted.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Com[illegible]

9.—PROBABLE DISCHARGES OF TH[illegible] [illegible] *iver at Winona, Minn., January 1,* [illegible] 1, 1882.

Table showing daily dischar[illegible]

[Computed from the gauge re[illegible] [illegible] from discharge observations at th[illegible]

NOTE.—As the Prescott ga[illegible] above Prescott), were taken[illegible]

Date.	Gauge.	Discharge in cubic feet per second.
1882.		
Jan. 1	180.8	
2	180.9	
3	181.0	
4	181.2	
5	181.4	
6	181.5	
7	181.6	

Discharge in 1,000 cubic feet per second.	Date.	Gauge.
	1882.	
36	May 29	442.7
35	30	442.6
35	31	442.6
35	June 1	442.5
35	2	442.4
36	3	442.3
37	4	442.3
37	5	442.3
36	6	442.1
35	7	442.0
35	8	442.0
36	9	441.9
38	10	441.8
39	11	441.7
44	12	441.5
48	13	441.3
50	14	441.2
51	15	441.0
52	16	440.8
53	17	440.5
56	18	440.3
62	19	440.1
64	20	439.9
75	21	439.6
84	22	439.6
90	23	439.8
96	24	440.2
100	25	440.3
104	26	440.4
104	27	441.6
101	28	441.7
99	29	442.1
97	30	442.3
95	July 1	442.3
91	2	442.3
89	3	442.3
88	4	442.4
86	5	442.3
86	6	442.1
86	7	442.1
86	8	442.1
84	9	442.1
84	10	441.9
84	11	441.8
84	12	441.8
82	13	441.7
82	14	441.7
80	15	441.7
79	16	441.7
78	17	441.7
78	18	441.7
76	19	441.5
74	20	441.1
72	21	440.8
71	22	440.6
71	23	440.2
71	24	440.0
71	25	439.8
72	26	439.6
77	27	439.6
86	28	439.3
95	29	439.1
97	30	439.0
96	31	439.0
95	Aug. 1	438.9
92	2	438.9
90	3	438.9
88	4	438.9
92	5	438.8
83	6	438.9
81	7	439.0
80	8	439.0
81	9	438.8
76	10	438.6

be done except to attend to the slope gauges. The remainder of the time of the assistant and recorder was occupied in computing some tables for reducing velocities. In this way much time was saved in the computations made during the working season. Mr. C. L. Harrison, recorder, was an able and reliable assistant. During my leave of absence, extending from the 12th to the 29th of September, he was in full charge of the observations, and executed the work with entire satisfaction. The assistant labored under great disadvantages, owing to the location of the station. It was frequently impracticable to carry out the instructions. In this case, the method was pursued that seemed, in the judgment of the assistant, best adapted to the circumstances.

Respectfully submitted.

J. H. DAVIS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

9.—PROBABLE DISCHARGES OF THE MISSISSIPPI RIVER AT VARIOUS POINTS, DURING THE YEARS 1881 AND 1882.

Table showing daily discharge of the Mississippi River at Prescott, Wis., January 1, 1882, *to January* 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations at the same point in 1881.]

NOTE.—As the Prescott gauge was not read in 1882, the gauge readings at Hastings, Minn. (3 miles above Prescott), were taken, after corrections for slope and changes of slope.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Jan. 1	180.8	18	Feb. 15	180.4	17	Apr. 1	184.2	33
2	180.9	18	16	180.4	17	2	184.7	35
3	181.0	19	17	180.4	17	3	185.2	37
4	181.2	19	18	180.5	17	4	185.7	39
5	181.4	20	19	180.5	17	5	186.2	42
6	181.5	20	20	180.5	17	6	186.7	46
7	181.6	21	21	180.6	17	7	187.2	50
8	181.7	21	22	180.6	17	8	187.7	54
9	181.9	22	23	180.7	18	9	188.2	58
10	181.8	22	24	180.7	18	10	188.7	63
11	181.8	22	25	180.6	17	11	189.2	68
12	181.7	21	26	180.5	17	12	189.7	73
13	181.6	21	27	180.4	17	13	190.3	80
14	181.7	21	28	180.5	17	14	190.2	79
15	181.7	21	Mar. 1	180.5	17	15	190.1	78
16	181.7	21	2	180.9	18	16	189.9	75
17	181.7	21	3	181.3	20	17	189.8	74
18	181.6	21	4	181.8	22	18	189.7	73
19	181.6	21	5	182.2	24	19	189.6	72
20	181.6	21	6	182.7	25	20	189.6	72
21	181.6	21	7	183.2	28	21	189.5	71
22	181.6	21	8	183.2	28	22	189.4	70
23	181.5	20	9	183.2	28	23	189.3	69
24	181.4	20	10	183.1	27	24	189.2	68
25	181.3	20	11	183.0	27	25	189.1	67
26	181.4	20	12	182.8	26	26	189.1	67
27	181.5	20	13	182.7	25	27	189.0	66
28	181.4	20	14	182.6	25	28	189.0	64
29	181.3	20	15	182.4	24	29	189.0	64
30	181.3	20	16	182.2	24	30	188.9	65
31	181.2	19	17	182.1	23	May 1	188.6	63
Feb. 1	181.2	19	18	182.1	23	2	188.5	62
2	181.2	19	19	182.1	23	3	188.3	60
3	181.1	19	20	182.1	23	4	188.2	59
4	181.0	19	21	182.2	24	5	188.0	57
5	180.9	18	22	182.2	24	6	187.8	55
6	180.9	18	23	182.1	23	7	187.6	53
7	180.8	18	24	182.2	24	8	187.4	52
8	180.8	18	25	182.3	24	9	187.2	50
9	180.7	18	26	182.3	24	10	187.4	52
10	180.7	18	27	182.4	24	11	187.6	53
11	180.6	17	28	182.7	25	12	188.1	56
12	180.6	17	29	183.1	27	13	188.6	62
13	180.5	17	30	183.4	28	14	189.2	66
14	180.5	17	31	183.8	30	15	189.8	74

be done [illegible]
ant and [illegible]
In this [illegible]
season [illegible]
leave of [illegible]
charge [illegible]
sistan [illegible]
was [illegible]
was [illegible]
cum [illegible]
He [illegible]

[illegible] River at Winona, Minn., January 1, 1882, [illegible] 1, 1883.

[illegible] obtained from discharge observations at the same [illegible] 1881.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
			1882.		
16	438.2	36	May 29	442.7	[illegible]
17	438.1	35	30	442.6	[illegible]
18	438.0	35	31	442.6	[illegible]
19	438.1	35	June 1	442.5	[illegible]
20	438.1	35	2	442.4	[illegible]
21	438.2	36	3	442.3	[illegible]
22	438.3	37	4	442.3	[illegible]
23	438.3	37	5	442.3	[illegible]
24	438.2	36	6	442.1	[illegible]
25	438.1	35	7	442.0	[illegible]
26	438.1	35	8	442.0	[illegible]
27	438.2	36	9	441.9	[illegible]
28	438.5	38	10	441.8	[illegible]
29	438.7	39	11	441.7	[illegible]
30	439.3	44	12	441.5	[illegible]
31	439.8	48	13	441.3	[illegible]
Apr. 1	440.1	50	14	441.2	[illegible]
2	440.2	51	15	441.0	[illegible]
3	440.3	52	16	440.8	[illegible]
4	440.4	53	17	440.5	[illegible]
5	440.8	56	18	440.3	[illegible]
6	441.4	62	19	440.1	[illegible]
7	441.6	64	20	439.9	[illegible]
8	442.7	75	21	439.6	[illegible]
9	443.6	84	22	439.6	[illegible]
10	444.2	90	23	439.8	[illegible]
11	444.7	96	24	440.2	[illegible]
12	445.1	100	25	440.3	[illegible]
13	445.4	104	26	440.4	[illegible]
14	445.4	104	27	441.0	[illegible]
15	445.2	101	28	441.7	[illegible]
16	445.0	99	29	442.1	[illegible]
17	444.8	97	30	442.3	[illegible]
18	444.6	95	July 1	442.3	[illegible]
19	444.3	91	2	442.3	[illegible]
20	444.1	89	3	442.3	[illegible]
21	444.0	88	4	442.4	[illegible]
22	443.8	86	5	442.3	[illegible]
23	443.8	86	6	442.1	[illegible]
24	443.8	86	7	442.1	[illegible]
25	443.8	86	8	442.1	[illegible]
26	443.6	84	9	442.1	[illegible]
27	443.6	84	10	441.9	[illegible]
28	443.6	84	11	441.8	[illegible]
29	443.6	84	12	441.8	[illegible]
30	443.4	82	13	441.7	[illegible]
May 1	443.4	82	14	441.7	[illegible]
2	443.2	80	15	441.7	[illegible]
3	443.1	79	16	441.7	[illegible]
4	443.0	78	17	441.7	[illegible]
5	443.0	78	18	441.7	[illegible]
6	442.8	76	19	441.5	[illegible]
7	442.6	74	20	441.1	[illegible]
8	442.4	72	21	440.8	[illegible]
9	442.3	71	22	440.6	[illegible]
10	442.3	71	23	440.2	[illegible]
11	442.3	71	24	440.0	[illegible]
12	442.3	71	25	439.8	[illegible]
13	442.4	72	26	439.6	[illegible]
14	442.9	77	27	439.6	[illegible]
15	443.8	86	28	439.3	[illegible]
16	444.6	95	29	439.1	[illegible]
17	444.8	97	30	439.0	[illegible]
18	444.7	96	31	439.0	[illegible]
19	444.6	95	Aug. 1	438.9	[illegible]
20	444.4	92	2	438.9	[illegible]
21	444.2	90	3	438.9	[illegible]
22	444.0	88	4	438.9	[illegible]
23	444.4	92	5	438.8	[illegible]
24	443.5	83	6	438.9	[illegible]
25	443.3	81	7	439.0	[illegible]
26	443.2	80	8	439.0	[illegible]
27	443.3	81	9	438.8	[illegible]
28	442.8	76	10	438.6	[illegible]

[illegible] *Mississippi River at Hannibal, Mo., &c.*—Con[illegible]

Date.		Gauge.	Discharge in 1,000 cubic feet per second.	Date.		Gauge.
1882.				1882.		
Apr.	24	86.5	247	July	10	84.6
	25	87.2	263		11	84.2
	26	87.9	280		12	84.0
	27	88.2	287		13	83.7
	28	88.2	287		14	83.4
	29	87.8	278		15	83.1
	30	87.5	271		16	82.9
May	1	87.1	261		17	82.6
	2	86.7	251		18	82.2
	3	86.2	240		19	82.0
	4	86.0	236		20	81.6
	5	85.7	229		21	81.2
	6	85.7	229		22	80.7
	7	86.4	244		23	80.4
	8	87.2	263		24	80.1
	9	87.6	273		25	79.9
	10	87.6	273		26	79.6
	11	87.6	273		27	79.4
	12	87.3	265		28	79.2
	13	87.0	258		29	79.1
	14	87.0	258		30	79.0
	15	86.8	253		31	79.1
	16	86.5	247	Aug.	1	79.2
	17	86.0	236		2	79.2
	18	85.5	225		3	79.0
	19	84.9	211		4	78.8
	20	84.3	198		5	78.9
	21	83.7	186		6	79.2
	22	83.1	174		7	78.9
	23	82.5	162		8	79.0
	24	82.1	154		9	78.6
	25	82.2	156		10	78.5
	26	82.3	158		11	78.2
	27	83.2	176		12	77.9
	28	84.7	207		13	77.6
	29	85.7	229		14	77.3
	30	86.3	242		15	77.2
	31	86.5	247		16	77.2
June	1	86.4	244		17	76.9
	2	86.5	247		18	76.7
	3	86.6	249		19	76.6
	4	86.9	255		20	76.5
	5	87.2	263		21	76.4
	6	87.2	263		22	76.4
	7	86.7	251		23	76.3
	8	85.8	231		24	76.2
	9	85.0	214		25	76.1
	10	84.2	196		26	76.0
	11	84.0	192		27	75.8
	12	84.7	207		28	75.6
	13	85.3	220		29	75.6
	14	85.9	233		30	75.6
	15	85.8	231		31	75.6
	16	85.6	227	Sept.	1	75.5
	17	85.2	218		2	75.5
	18	84.5	203		3	75.5
	19	83.7	186		4	75.6
	20	83.2	176		5	75.7
	21	82.7	168		6	75.8
	22	82.9	170		7	76.1
	23	82.4	160		8	76.3
	24	82.4	160		9	76.5
	25	82.7	166		10	76.4
	26	83.0	172		11	76.3
	27	84.2	196		12	76.2
	28	85.2	218		13	76.2
	29	86.3	247		14	76.0
	30	87.6	273		15	75.9
July	1	88.1	285		16	75.7
	2	88.4	292		17	75.6
	3	88.2	287		18	75.5
	4	87.9	280		19	75.5
	5	87.4	268		20	75.3
	6	86.9	255		21	75.2
	7	86.2	240		22	75.0
	8	85.2	218		23	74.8
	9	84.8	211		24	74.7

wing daily discharge of the Mississippi River at Hannibal, Mo., &c.—Continued.

Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
		1882.			1882.		
74.6	47	Oct. 28	77.2	77	Nov. 30	77.0	74
74.5	46	29	77.2	77	Dec. 1	76.7	70
74.4	45	30	77.2	77	2	76.5	68
74.3	44	31	77.2	77	3	76.3	65
74.3	44	Nov. 1	77.2	77	4	76.2	64
74.2	43	2	77.1	75	5	75.9	60
74.2	43	3	77.1	75	6	75.8	59
74.2	43	4	76.9	72	7	75.1	52
74.2	43	5	76.7	70	8	74.6	47
74.2	43	6	76.5	68	9	74.0	41
74.1	42	7	76.3	65	10	73.6	37
74.1	42	8	76.2	64	11	72.6	27
74.1	42	9	76.0	62	12	71.6	17
74.1	42	10	76.0	62	13	71.7	18
74.1	42	11	76.0	62	14	72.2	23
74.2	43	12	76.0	62	15	72.1	22
74.2	43	13	75.9	60	16	73.0	31
74.4	45	14	75.8	59	17	71.9	20
74.7	48	15	75.7	58	18	72.0	21
74.7	48	16	75.6	57	19	71.7	18
74.7	48	17	76.2	64	20	72.4	25
75.1	52	18	76.4	66	21	73.2	33
75.6	57	19	76.5	68	22	74.0	41
76.0	62	20	76.6	69	23	74.8	49
76.2	64	21	76.7	70	24	75.1	52
76.2	64	22	76.7	70	25	75.2	53
76.2	64	23	76.8	71	26	75.5	56
76.3	65	24	76.9	72	27	75.6	57
76.6	69	25	77.1	75	28	75.9	60
76.7	70	26	77.1	75	29	76.0	62
76.9	72	27	77.2	77	30	76.0	62
77.0	74	28	77.2	77	31	75.8	59
77.2	77	29	77.2	77			

ing daily discharge of the Mississippi River at Grafton, Ill., January 1, 1882, *to January* 1, 1883.

from the gauge readings by a formula deduced from discharge observations at the same point in 1881.]

Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
		1882.			1882.		
23.7	153	Jan. 27	18.3	75	Feb. 22	29.7	270
23.0	142	28	18.3	75	23	29.2	259
22.6	135	29	18.1	73	24	26.2	197
22.3	131	30	17.9	70	25	24.7	170
22.0	126	31	18.2	74	26	22.9	141
1.7	121	Feb. 1	18.3	75	27	21.8	122
1.3	115	2	18.5	77	28	21.3	115
.0	110	3	18.3	75	Mar. 1	21.7	121
1	112	4	18.2	74	2	22.1	127
0	110	5	18.7	79	3	21.9	124
9	109	6	18.7	79	4	22.0	126
	106	7	18.7	79	5	22.2	129
	105	8	18.7	79	6	22.5	134
	105	9	18.8	80	7	22.7	137
	105	10	18.9	81	8	23.0	142
	96	11	18.7	79	9	23.3	147
	90	12	18.5	77	10	24.2	161
	85	13	18.6	78	11	25.1	177
	81	14	18.6	78	12	25.6	186
	79	15	18.6	78	13	25.4	183
	75	16	18.5	77	14	25.0	176
	72	17	18.9	81	15	24.7	170
	70	18	19.1	84	16	24.4	165
	72	19	19.3	86	17	24.3	163
	75	20	24.5	167	18	24.2	161
	75	21	28.7	247	19	24.2	161

—168

Table showing daily discharge of the Mississippi River at Grafton, Ill., &c.—Contir

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Dis in cub per
1882.			1882.			1882.		
Mar. 20	24.4	165	June 5	32.0	324	Aug. 21	18.8	
21	24.6	168	6	32.0	324	22	18.6	
22	25.1	177	7	32.1	326	23	18.5	
23	25.2	179	8	32.1	326	24	18.4	
24	25.2	179	9	31.9	321	25	18.4	
25	25.2	179	10	31.5	312	26	18.4	
26	25.1	177	11	31.2	305	27	18.3	
27	25.1	177	12	30.6	290	28	18.1	
28	25.0	176	13	30.4	285	29	17.9	
29	25.0	176	14	30.4	285	30	17.7	
30	25.1	177	15	30.6	290	31	17.5	
31	25.1	177	16	30.8	295	Sept. 1	17.7	
Apr. 1	25.1	177	17	31.3	307	2	17.9	
2	25.2	179	18	31.7	317	3	17.7	
3	25.3	181	19	31.6	314	4	17.7	
4	25.5	185	20	31.2	305	5	17.7	
5	25.6	186	21	30.9	297	6	17.9	
6	25.5	185	22	30.7	292	7	17.9	
7	25.5	185	23	30.3	283	8	18.1	
8	25.3	181	24	30.1	279	9	18.3	
9	25.6	186	25	29.7	270	10	18.4	
10	25.5	185	26	29.4	263	11	18.4	
11	25.8	190	27	29.7	270	12	18.4	
12	26.1	195	28	30.1	279	13	18.2	
13	26.4	201	29	30.7	292	14	18.1	
14	26.8	209	30	31.5	312	15	18.0	
15	27.1	215	July 1	32.5	336	16	17.8	
16	27.4	221	2	33.1	350	17	17.8	
17	27.5	223	3	34.0	374	18	17.5	
18	27.9	231	4	34.5	387	19	17.3	
19	27.8	229	5	34.7	392	20	17.2	
20	27.2	217	6	34.7	392	21	17.1	
21	27.1	215	7	34.5	387	22	16.9	
22	27.3	219	8	34.2	379	23	16.7	
23	28.3	239	9	33.7	366	24	16.6	
24	29.1	257	10	33.0	348	25	16.5	
25	29.6	268	11	32.3	331	26	16.4	
26	30.2	281	12	31.7	317	27	16.3	
27	30.6	290	13	30.9	297	28	16.1	
28	30.8	295	14	30.2	281	29	16.1	
29	31.1	302	15	29.5	266	30	16.0	
30	31.2	305	16	28.9	252	Oct. 1	15.9	
May 1	31.2	305	17	28.3	239	2	15.9	
2	31.1	302	18	27.9	231	3	15.8	
3	30.9	297	19	27.4	221	4	15.7	
4	30.6	290	20	27.0	213	5	15.7	
5	30.2	281	21	26.5	203	6	15.7	
6	29.6	268	22	25.2	179	7	15.6	
7	28.5	243	23	24.8	172	8	15.6	
8	28.5	243	24	24.6	168	9	15.6	
9	30.3	283	25	24.4	165	10	15.6	
10	30.4	285	26	24.0	158	11	15.7	
11	31.1	302	27	23.5	150	12	15.7	
12	31.3	307	28	23.1	143	13	15.7	
13	31.3	307	29	22.8	139	14	15.9	
14	31.3	307	30	22.6	135	15	16.2	
15	31.2	305	31	22.3	131	16	16.3	
16	31.1	302	Aug. 1	22.1	127	17	16.4	
17	31.0	300	2	22.0	126	18	16.9	
18	30.6	290	3	22.0	126	19	17.5	
19	30.7	292	4	21.9	124	20	17.7	
20	30.4	285	5	21.7	121	21	17.8	
21	30.0	277	6	21.7	121	22	17.9	
22	28.5	243	7	21.9	124	23	18.0	
23	28.9	252	8	21.9	124	24	18.0	
24	28.1	235	9	21.8	122	25	18.1	
25	27.9	231	10	21.5	118	26	18.1	
26	27.0	213	11	21.2	113	27	18.2	
27	27.1	215	12	20.8	108	28	18.4	
28	28.2	237	13	20.4	102	29	18.6	
29	29.3	261	14	20.1	97	30	18.7	
30	29.9	274	15	19.9	94	31	18.8	
31	30.6	290	16	19.8	93	Nov. 1	18.9	
June 1	31.3	307	17	19.7	92	2	18.9	
2	31.5	312	18	19.5	89	3	18.8	
3	31.8	319	19	19.2	85	4	18.7	
4	32.0	324	20	19.0	83	5	18.6	

ving daily discharge of the Mississippi River at Grafton, Ill., &c.—Continued.

Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
		1882.			1882.		
18.5	77	Nov. 25	18.8	80	Dec. 14	13.8	31
18.2	74	26	18.9	81	15	13.8	31
18.1	73	27	18.9	81	16	14.0	33
18.0	72	28	19.0	83	17	14.2	34
17.8	69	29	19.1	84	18	14.2	34
17.7	68	30	19.2	85	19	14.4	36
17.6	67	Dec. 1	19.3	86	20	14.7	39
17.7	68	2	19.2	85	21	14.7	39
17.9	70	3	18.5	77	22	15.1	42
17.8	69	4	18.2	74	23	15.9	50
17.7	68	5	17.9	70	24	16.4	55
17.8	69	6	17.5	66	25	16.9	60
17.8	69	7	17.2	63	26	17.3	64
18.1	73	8	16.7	58	27	17.5	66
18.2	74	9	16.2	53	28	17.5	66
18.4	76	10	15.2	43	29	17.6	67
18.4	76	11	14.8	40	30	17.7	68
18.6	78	12	14.2	34	31	17.7	68
18.6	78	13	14.0	33			

ving daily discharge of Mississippi River at Fulton, Tenn., January 1, 1881, to January 1, 1883.

from the gauge readings by a formula deduced from discharge observations at the same point extending from November, 1879, to November, 1880.]

OTE.—I in the column of remarks means that gauge-readings were interpolated.

Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
			1881.			
157.86	109		Feb. 17	182.58	876	
157.86	109		18	183.03	895	
158.10	114	I.	19	183.37	910	
158.34	119	I.	20	183.76	928	
158.69	126		21	184.15	947	
159.54	142		22	184.53	963	
160.86	170		23	184.89	982	
162.13	218		24	185.18	996	
164.50	262		25	185.45	1,010	
165.86	278	I.	26	185.61	1,018	
166.10	295	I.	27	185.83	1,027	
166.90	318	I.	28	185.94	1,032	
167.71	337		Mar. 1	185.92	1,031	
169.09	377		2	185.83	1,027	
171.10	442		3	185.61	1,016	I.
172.14	507		4	185.39	1,007	
174.89	568		5	184.90	982	
176.15	610		6	184.07	944	
177.05	648		7	182.89	889	
177.05	672		8	181.48	827	
178.02	687		9	180.01	767	
178.14	691		10	178.75	716	
177.84	680		11	178.16	692	
177.03	648		12	177.27	657	
176.01	610		13	176.69	637	
174.37	549		14	176.29	621	
172.03	488		15	176.10	614	
170.89	439		16	176.08	613	
169.58	395		17	177.22	655	
168.44	350		18	178.09	690	
167.64	335		19	178.68	713	
167.56	327		20	179.28	738	
167.57	332		21	180.20	775	
171.85	464	I.	22	181.26	818	
174.03	538	I.	23	182.27	862	
177.03	647	I.	24	182.65	879	
179.40	743		25	183.09	899	
181.39	820		26	183.38	911	
181.95	847		27	183.56	919	

Table showing daily discharge of the Mississippi River at Fulton, Tenn., &c.—Con

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1881.			
Mar. 28	183.71	926	
29	183.84	932	
30	184.83	979	
31	183.75	928	
Apr. 1	183.45	914	
2	183.20	903	
3	182.95	891	
4	182.87	887	
5	182.76	883	
6	182.53	874	
7	182.30	863	
8	181.99	850	
9	181.65	835	
10	181.67	835	
11	181.92	846	
12	182.41	868	
13	182.95	891	
14	183.49	917	
15	184.10	945	
16	184.68	971	
17	185.18	996	
18	185.68	1,020	
19	186.11	1,040	
20	186.46	1,058	
21	186.78	1,074	
22	187.12	1,090	
23	187.33	1,099	
24	187.79	1,121	
25	187.99	1,131	
26	188.09	1,136	High water.
27	188.07	1,135	
28	187.98	1,130	
29	187.96	1,129	
30	187.85	1,123	
May 1	187.67	1,114	
2	187.35	1,100	
3	187.18	1,093	
4	187.05	1,087	
5	186.99	1,085	
6	186.94	1,082	
7	186.93	1,082	
8	186.95	1,082	
9	186.97	1,083	
10	187.05	1,087	
11	187.07	1,086	
12	187.00	1,085	
13	186.87	1,078	
14	186.53	1,067	
15	185.90	1,030	
16	185.07	990	
17	184.08	944	
18	183.05	896	
19	181.68	836	
20	180.73	796	
21	179.59	750	
22	178.69	714	
23	177.92	683	
24	177.13	651	
25	176.35	623	
26	175.73	600	
27	175.31	583	
28	175.07	575	
29	174.86	566	
30	174.55	554	
31	174.02	537	
June 1	173.36	511	
2	172.69	491	
3	171.96	468	
4	171.37	450	
5	170.97	438	
6	170.58	422	
7	170.50	420	
8	170.64	424	
9	170.78	430	I.
10	170.72	428	
11	170.48	419	
12	170.26	412	
13	170.18	410	
1881.			
June 14	170.26	412	
15	170.88	434	
16	171.58	456	
17	172.32	478	
18	172.96	499	
19	173.96	533	
20	174.96	570	
21	176.27	620	
22	176.86	642	I.
23	177.45	664	
24	177.54	668	
25	177.35	660	
26	176.59	633	
27	176.34	622	
28	175.77	601	
29	175.19	580	
30	174.64	558	
July 1	174.18	542	
2	173.71	524	
3	173.29	510	
4	173.08	503	
5	173.25	508	
6	173.43	514	
7	173.61	520	I.
8	173.68	523	I.
9	173.57	519	
10	173.15	505	
11	172.52	485	
12	171.67	458	
13	170.71	427	
14	169.78	400	
15	168.93	374	
16	168.23	353	
17	167.96	345	
18	168.02	346	
19	168.31	355	
20	168.60	364	
21	168.84	371	
22	169.00	377	
23	169.23	384	
24	169.41	389	
25	169.49	392	
26	169.52	393	
27	169.44	390	
28	169.20	383	
29	168.97	376	
30	168.49	361	
31	167.74	338	
Aug. 1	167.04	321	
2	166.37	303	
3	165.88	289	
4	165.50	279	
5	165.29	273	
6	165.08	267	
7	164.89	263	
8	164.71	257	
9	164.49	252	
10	164.20	244	
11	163.84	236	
12	163.42	224	
13	163.06	217	
14	162.63	207	
15	162.27	199	
16	161.90	191	
17	161.78	188	
18	161.53	183	
19	161.41	181	
20	161.10	175	
21	162.53	205	
22	161.96	192	
23	161.81	189	
24	161.66	186	
25	161.53	183	
26	161.41	181	
27	161.31	179	
28	160.02	151	
29	158.82	128	
30	159.68	145	

Date	Gauge reading	
1862. Jan. 1	[illegible]	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	[illegible]	[illegible]
7	[illegible]	[illegible]
8	[illegible]	[illegible]
9	[illegible]	[illegible]
10	[illegible]	[illegible]
11	[illegible]	[illegible]
12	[illegible]	[illegible]
13	[illegible]	[illegible]
14	[illegible]	[illegible]
15	[illegible]	[illegible]
16	[illegible]	[illegible]
17	[illegible]	[illegible]
18	31.65	[illegible]
19	[illegible]	[illegible]
20	[illegible]	[illegible]
21	33.12	[illegible]
22	33.54	[illegible]
23	33.92	[illegible]
24	34.36	[illegible]
25	[illegible]	[illegible]
26	35.02	[illegible]
27	35.32	[illegible]
28	35.50	[illegible]

(…12) = zero of gauge established December, 1861.

Table showing daily discharge of Mississippi River at Fulton, Tenn., &c.—Conti

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Ren
1882.				1882.			
Jan. 29	35.62	1,224		Apr. 17	27.81	845	
30	35.67	1,226		18	27.88	848	
31	35.78	1,234		19	27.92	851	
Feb. 1	35.74	1,231		20	27.61	837	
2	35.71	1,229		21	27.08	815	
3	35.74	1,231		22	26.24	781	
4	35.74	1,231		23	25.61	755	
5	35.65	1,226		24	24.70	718	
6	35.65	1,226		25	24.05	692	
7	35.64	1,226		26	23.93	687	
8	35.66	1,226		27	23.82	683	
9	35.69	1,228		28	23.96	688	
10	35.67	1,226		29	24.21	698	
11	35.59	1,223		30	24.46	708	
12	35.50	1,217		May 1	24.73	719	
13	35.51	1,217		2	24.87	724	
14	35.37	1,211		3	24.96	729	
15	35.23	1,201		4	25.11	735	
16	35.18	1,199		5	25.22	740	
17	35.11	1,194		6	25.25	741	
18	35.05	1,191		7	25.05	733	
19	35.03	1,190		8	24.86	724	
20	35.12	1,194		9	24.63	715	
21	35.17	1,199		10	25.35	745	
22	35.23	1,201		11	27.02	813	
23	35.32	1,207		12	28.58	880	
24	35.59	1,222		13	29.88	939	
25	35.89	1,239		14	30.85	984	
26	36.19	1,255		15	31.63	1,022	
27	36.43	1,268		16	32.16	1,047	
28	36.63	1,278		17	32.52	1,066	
Mar. 1	36.69	1,282		18	32.67	1,073	
2	36.66	1,279		19	32.70	1,075	
3	36.60	1,277		20	32.69	1,075	
4	36.51	1,272		21	32.85	1,082	
5	36.44	1,269		22	32.83	1,081	
6	36.44	1,269		23	32.79	1,080	
7	36.38	1,266		24	32.81	1,080	
8	36.28	1,260		25	32.80	1,080	
9	36.26	1,259		26	32.68	1,074	
10	36.18	1,255		27	32.51	1,065	
11	36.11	1,250		28	32.14	1,047	
12	36.04	1,247		29	31.59	1,021	
13	36.04	1,247		30	31.04	994	
14	36.13	1,251		31	30.66	975	
15	36.13	1,251		June 1	30.66	975	
16	36.00	1,245		2	30.81	982	
17	35.86	1,237		3	31.00	992	
18	35.76	1,232		4	31.27	1,006	
19	35.68	1,226		5	31.55	1,018	
20	35.62	1,224		6	31.71	1,026	
21	35.52	1,218		7	31.85	1,032	
22	35.44	1,214		8	31.97	1,039	
23	35.17	1,197		9	32.04	1,042	
24	34.97	1,187		10	32.07	1,044	
25	34.73	1,172		11	32.07	1,044	
26	34.49	1,160		12	31.96	1,039	
27	34.25	1,148		13	31.69	1,026	
28	33.96	1,133		14	31.25	1,005	
29	33.68	1,120		15	30.50	967	
30	33.42	1,108		16	29.49	921	
31	33.25	1,100		17	28.45	874	
Apr. 1	33.11	1,094		18	27.45	830	
2	32.96	1,087		19	27.90	850	
3	32.84	1,082		20	27.21	820	
4	32.70	1,075		21	27.86	847	
5	32.58	1,069		22	28.59	881	
6	32.30	1,055		23	29.01	899	
7	31.79	1,030		24	29.35	914	
8	31.10	997		25	29.61	926	
9	30.16	950		26	29.79	935	
10	29.33	913		27	29.81	935	
11	29.05	901		28	29.69	930	
12	28.79	889		29	29.39	917	
13	28.62	882		30	29.09	903	
14	28.41	872		July 1	28.56	879	
15	28.05	856		2	28.37	870	
16	27.87	848		3	28.26	865	

Table showing daily discharge of Mississippi River at Fulton, Tenn., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1882.			
July 4	28.29	868	
5	28.62	882	
6	28.89	894	
7	29.20	906	
8	29.58	921	
9	29.82	936	
10	30.08	946	
11	30.13	950	
12	30.12	950	
13	29.89	940	
14	29.74	887	
15	28.41	872	L.
16	28.04	856	
17	27.30	824	
18	26.61	795	
19	25.82	764	
20	25.02	732	
21	24.31	702	
22	23.69	678	
23	23.17	657	
24	22.70	641	
25	22.15	619	
26	21.40	590	
27	20.52	557	
28	19.50	520	
29	18.64	492	
30	18.87	500	
31	18.22	478	
Aug. 1	17.52	457	
2	17.31	451	
3	17.00	442	
4	16.74	433	
5	16.43	421	
6	16.41	420	
7	16.76	433	
8	17.62	460	
9	18.34	482	
10	18.58	490	
11	18.54	488	
12	18.39	484	
13	18.15	476	
14	17.78	465	
15	17.63	461	
16	17.15	446	
17	16.40	420	
18	15.84	404	
19	15.60	398	
20	15.36	390	
21	15.11	383	
22	14.83	374	
23	14.44	362	
24	13.97	348	
25	13.55	335	
26	13.06	323	
27	12.62	314	
28	12.21	301	
29	11.91	292	
30	11.74	288	
31	11.54	282	
Sept. 1	11.42	279	
2	11.42	279	
3	11.42	279	
4	11.41	279	
5	11.41	279	
6	11.48	280	
7	11.61	284	
8	11.75	288	
9	11.95	293	
10	12.10	298	
11	12.13	299	
12	12.01	295	
13	11.85	291	
14	11.65	286	
15	11.47	280	
16	11.19	273	
17	11.00	268	
18	11.02	268	
19	11.57	283	
1882.			
Sept. 20	12.47	309	
21	13.02	322	
22	13.60	337	
23	13.52	334	
24	13.01	322	
25	12.33	305	
26	11.84	291	
27	11.30	276	
28	10.76	261	
29	10.30	248	
30	9.85	238	
Oct. 1	9.53	230	
2	9.31	224	
3	9.02	218	
4	8.84	214	
5	8.75	212	
6	8.79	213	
7	8.79	213	
8	8.77	212	
9	8.70	211	
10	8.63	210	
11	8.60	209	
12	8.58	208	
13	8.57	208	
14	8.48	207	
15	8.40	205	
16	8.30	202	
17	8.20	200	
18	8.01	196	
19	7.92	195	
20	7.82	192	
21	7.73	190	
22	7.70	189	
23	7.76	190	
24	7.87	193	
25	7.98	196	
26	8.05	197	
27	8.08	198	
28	8.06	198	
29	8.10	198	
30	8.13	198	
31	8.18	199	
Nov. 1	8.30	202	
2	8.30	202	
3	8.33	203	
4	8.38	204	
5	8.47	206	
6	8.51	207	
7	8.50	207	
8	8.51	207	
9	8.54	208	
10	8.54	208	
11	8.77	212	
12	9.11	220	
13	9.18	222	
14	9.39	227	
15	9.59	232	
16	9.70	235	
17	9.68	234	
18	9.74	236	
19	9.86	238	
20	9.90	240	
21	9.78	236	
22	9.62	233	
23	9.54	230	
24	9.41	227	
25	9.22	222	
26	9.18	222	
27	9.12	220	
28	9.08	219	
29	9.03	218	
30	9.08	219	
Dec. 1	9.09	219	
2	9.10	220	
3	9.11	220	
4	9.12	220	
5	9.11	220	
6	9.11	220	

discharge of Mississippi River at Fulton

Date.	Gauge.	ischarge in 1,000 ubic feet er second.	Remarks.	Date.	Gauge
				1882.	
		1,224		Apr. 17	27.
		1,226		18	27.
		1,234		19	27.
		1,231		20	27.
2		1,229		21	27.
3		1,231		22	26.
4		1,231		23	25.
5		1,226		24	24.
	[illegible]	1,226		25	24.
	[illegible]	1,226		26	23.
	[illegible]	1,226		27	23.
	[illegible]	1,228		28	23.
	[illegible]	1,226		29	24.
	35.59	1,223		30	24.
	35.50	1,217		May 1	24.
	35.51	1,217		2	24.
	35.37	1,211		3	24.
	35.23	1,201		4	25.
	35.18	1,199		5	25.
	35.11	1,194		6	25.
	35.05	1,191		7	25.
	35.03	1,190		8	[illegible]
	35.12	1,194		9	[illegible]
	35.17	1,199		10	[illegible]
	35.23	1,201		11	[illegible]
	35.32	1,207		12	[illegible]
	35.59	1,222		13	[illegible]
	35.89	1,239		14	
	36.19	1,255		15	
	36.43	1,268		16	
	36.63	1,278		17	
	36.69	1,282		18	
	36.66	1,279		19	
	36.60	1,277		20	
4	36.51	1,272		21	
5	36.44	1,269		22	
6	36.44	1,269		23	
7	36.38	1,266		24	
8	36.28	1,260		25	
9	36.26	1,259		26	
10	36.18	1,255		27	
11	36.11	1,250		28	
12	36.04	1,247		29	
13	36.04	1,247		30	
14	36.13	1,251		31	
15	36.13	1,251		June	
16	36.00	1,245			
17	35.86	1,237			
18	35.76	1,232			
19	35.68	1,226			
20	35.62	1,224			
21	35.52	1,218			
22	35.44	1,214			
23	35.17	1,197			
24	34.97	1,187			
25	34.73	1,172			
26	34.49	1,160			
27	34.25	1,148			
28	33.96	1,133			
29	33.68	1,120			
30	33.42	1,108			
31	33.25	1,100			
Apr. 1	33.11	1,094			
2	32.96	1,087			
3	32.84	1,082			
4	32.70	1,075			
5	32.58	1,069			
6	32.30	1,055			
7	31.79	1,030			
8	31.10	997			
9	30.16	950			
10	29.33	913			
11	29.05	901			
12	28.79	889			
13	28.62	882			
14	28.41	872			
15	28.05	856			
16	27.87	848			

Table showing daily discharge of Mississippi [illegible] at Memphis, Tenn., &c.—Con

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1882.			
Dec. 7	9.25	223	
8	9.46	228	
9	9.50	229	
10	9.34	225	
11	9.06	219	
12	8.74	212	
13	8.47	206	
14	8.17	200	
15	7.86	193	
16	7.47	184	
17	7.22	179	
18	7.04	176	
19	6.78	169	

Table showing daily discharge of the Mi[illegible] to Ja[illegible]

[Computed from the gauge readings, by a f[illegible] Landing, Ark., 1879–1880 (12 miles below [illegible] gauge readings.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1881.		
Jan. 1	....	....
2	6.45	211
3	5.55	193
4	4.35	169
5	3.50	152
6	2.95	141
7	2.70	136
8	2.55	133
9	2.45	131
10	2.35	129
11	2.38	130
12	2.38	130
13	2.62	134
14	3.22	126
15	4.04	163
16	5.80	198
17	7.90	249
18	9.30	279
19	10.40	309
20	11.30	326
21	12.30	360
22	13.30	383
23	15.30	431
24	17.30	508
25	18.30	523
26	20.90	621
27	21.20	666
28	23.60	693
29	25.60	725
30	25.80	727
31	25.80	727
Feb. 1	25.30	711
2	[illegible]	680
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	[illegible]	[illegible]
7	[illegible]	[illegible]
8	[illegible]	[illegible]
9	[illegible]	[illegible]
10	[illegible]	[illegible]
11	[illegible]	[illegible]
12	[illegible]	[illegible]
13	[illegible]	[illegible]
14	[illegible]	[illegible]

Discharge in 1,000 cubic feet per second.	Date.	Gauge.
	1882.	
1,125	June 12	31.5
1,117	13	31.4
1,118	14	31.3
1,105	15	30.9
1,097	16	30.1
1,089	17	29.2
1,082	18	28.4
1,074	19	27.6
1,067	20	27.2
1,067	21	27.2
1,059	22	27.8
1,054	23	28.5
1,042	24	29.0
1,024	25	29.2
993	26	29.3
960	27	29.4
930	28	29.5
914	29	29.5
902	30	29.1
894	July 1	28.8
882	2	28.5
872	3	28.2
862	4	28.1
862	5	28.0
866	6	28.0
862	7	28.5
847	8	28.9
824	9	29.2
792	10	29.5
762	11	29.7
733	12	30.0
707	13	29.8
693	14	29.65
680	15	29.2
707	16	28.5
720	17	27.8
733	18	27.1
740	19	26.3
744	20	25.5
747	21	24.6
751	22	23.7
755	23	23.0
755	24	22.5
751	25	21.9
731	26	21.3
773	27	20.3
838	28	19.3
902	29	18.2
935	30	17.2
965	31	16.3
987	Aug. 1	15.5
1,009	2	15.0
1,026	3	14.5
1,034	4	14.3
1,042	5	14.0
1,047	6	13.7
1,052	7	13.7
1,057	8	14.4
1,057	9	15.2
1,057	10	15.9
1,057	11	16.1
1,054	12	16.0
1,052	13	15.8
1,044	14	15.6
1,032	15	15.3
1,016	16	15.0
1,002	17	14.6
979	18	14.1
977	19	13.8
961	20	13.6
959	21	13.4
987	22	13.2
1,001	23	12.8
1,009	24	12.3
1,016	25	11.8
1,022	26	11.3
1,026	27	10.8
1,029	28	10.2

·iver at *Memphis, Tenn., &c.*—Continued.

	..	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
			1882.		
	5.4	190	Nov. 21	7.25	[illegible]
	5.4	190	22	7.25	[illegible]
	5.4	190	23	7.00	[illegible]
	5.4	190	24	6.75	[illegible]
	5.4	190	25	6.60	[illegible]
	5.25	189	26	6.55	[illegible]
	5.22	186	27	6.50	[illegible]
	5.13	184	28	6.45	211
	5.13	184	29	6.40	[illegible]
	4.84	179	30	6.35	[illegible]
	4.68	175	Dec. 1	6.30	[illegible]
	4.55	173	2	6.25	[illegible]
	4.55	173	3	6.25	[illegible]
	4.47	171	4	6.20	[illegible]
	4.47	171	5	6.40	[illegible]
	4.84	178	6	6.40	[illegible]
	4.88	180	7	6.45	[illegible]
	4.97	181	8	6.60	[illegible]
	4.97	181	9	[illegible]	[illegible]
4	4.97	181	10	6.60	214
30	4.98	181	11	6.50	[illegible]
31	5.01	182	12	6.25	[illegible]
1	5.13	184	13	6.00	[illegible]
2	5.18	185	14	5.70	[illegible]
3	5.22	186	15	5.25	[illegible]
4	5.22	186	16	4.85	[illegible]
5	5.34	188	17	4.45	[illegible]
6	5.43	190	18	[illegible]	[illegible]
7	5.47	191	19	4.00	[illegible]
8	5.51	192	20	3.75	[illegible]
9	5.52	192	21	3.50	[illegible]
10	5.54	192	22	3.55	[illegible]
11	5.55	193	23	3.75	[illegible]
12	5.97	201	24	4.15	[illegible]
13	6.18	205	25	4.90	[illegible]
14	6.26	207	26	[illegible]	[illegible]
15	6.47	211	27	6.30	[illegible]
16	6.76	217	28	7.20	[illegible]
17	6.85	220	29	8.20	[illegible]
18	7.00	225	30	9.00	271
19	7.10	228	31	9.70	[illegible]
20	7.20	230			

·ge *of the Mississippi River at Carrollton, La., January* 1, 1881, *to January* 1, 1883.

··adings by a formula deduced from discharge observations at the same ··xtending from December, 1879, to October, 1880.]

··arge ·,000 ·· feet ·econd.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
	1881.			1881.		
....	Jan. 20	2.1	296	Feb. 8	10.4	681
[illegible]	21	2.0	292	9	10.4	681
[illegible]	22	2.1	296	10	10.0	661
451	23	2.4	308	11	10.1	666
[illegible]	24	3.0	333	12	9.9	656
[illegible]	25	3.2	342	13	9.6	641
[illegible]	26	3.6	361	14	9.3	626
374	27	4.1	383	15	9.3	626
[illegible]	28	4.8	415	16	9.3	626
[illegible]	29	5.6	451	17	9.4	631
[illegible]	30	6.5	492	18	9.8	651
312	31	7.2	530	19	10.3	676
[illegible]	Feb. 1	7.9	562	20	10.6	691
[illegible]	2	8.3	578	21	10.8	701
[illegible]	3	8.6	591	22	11.3	726
[illegible]	4	8.9	606	23	11.4	731
[illegible]	5	9.3	626	24	11.6	742
[illegible]	6	10.0	661	25	11.9	758
[illegible]	7	10.6	691	26	12.0	764

Table showing daily discharge of Mississippi River at Carrollton, La., &c.—Contin

Date.		Gauge.	Discharge in 1,000 cubic feet per second.	Date.		Gauge.	Discharge in 1,000 cubic feet per second.	Date.		Gauge.	Di in cul per
1881.				1881.				1881.			
Feb.	27	12.3	780	May	16	12.1	769	Aug.	2	4.8	
	28	12.1	769		17	12.0	764		3	4.4	
Mar.	1	12.2	774		18	12.1	769		4	3.9	
	2	12.0	764		19	12.1	769		5	3.6	
	3	12.1	769		20	12.1	769		6	3.3	
	4	12.2	774		21	12.25	777		7	3.2	
	5	12.2	774		22	12.3	780		8	2.8	
	6	12.1	769		23	12.3	780		9	2.5	
	7	12.2	774		24	12.3	780		10	2.1	
	8	12.0	764		25	12.3	780		11	1.9	
	9	12.0	764		26	12.4	785		12	1.7	
	10	12.2	774		27	12.3	780		13	1.7	
	11	12.3	780		28	12.3	780		14	1.7	
	12	12.4	785		29	12.3	780		15	1.6	
	13	12.3	780		30	12.4	785		16	1.8	
	14	12.4	785		31	12.3	780		17	2.0	
	15	12.5	790	June	1	12.3	780		18	2.0	
	16	12.5	790		2	12.2	774		19	1.7	
	17	12.4	785		3	12.2	774		20	1.4	
	18	12.3	780		4	12.2	774		21	1.1	
	19	12.3	780		5	12.2	774		22	1.0	
	20	12.2	774		6	12.2	774		23	1.0	
	21	12.3	780		7	12.2	774		24	0.8	
	22	11.9	758		8	12.2	774		25	0.8	
	23	12.1	769		9	12.0	764		26	1.0	
	24	12.1	769		10	12.0	764		27	1.0	
	25	12.1	769		11	11.9	758		28	0.7	
	26	12.2	774		12	11.6	742		29	0.8	
	27	12.2	774		13	11.3	726		30	0.8	
	28	12.3	780		14	11.1	716		31	1.3	
	29	12.4	785		15	10.9	706	Sept.	1	1.4	
	30	12.25	777		16	10.8	701		2	1.5	
	31	12.2	774		17	10.7	696		3	1.5	
Apr.	1	12.2	774		18	10.5	686		4	1.4	
	2	12.2	774		19	10.3	676		5	1.3	
	3	12.2	774		20	10.2	671		6	1.1	
	4	12.3	780		21	10.1	666		7	0.8	
	5	12.3	780		22	10.0	661		8	0.7	
	6	12.3	780		23	9.75	648		9	0.5	
	7	12.3	780		24	9.6	641		10	0.3	
	8	12.4	785		25	9.6	641		11	0.4	
	9	12.4	785		26	9.6	641		12	0.6	
	10	12.4	785		27	9.6	641		13	0.8	
	11	12.4	785		28	9.8	651		14	1.15	
	12	12.55	792		29	9.9	656		15	1.5	
	13	12.5	790		30	9.95	658		16	1.1	
	14	12.3	780	July	1	9.9	656		17	1.1	
	15	12.3	780		2	9.9	656		18	1.3	
	16	12.2	774		3	10.0	661		19	1.2	
	17	12.0	764		4	10.0	661		20	1.0	
	18	12.1	769		5	9.9	656		21	0.9	
	19	12.1	769		6	9.8	651		22	0.7	
	20	12.0	764		7	9.6	641		23	0.65	
	21	12.1	769		8	9.4	631		24	0.7	
	22	12.1	769		9	9.2	621		25	0.8	
	23	12.2	774		10	9.1	616		26	1.0	
	24	12.4	785		11	8.7	596		27	1.2	
	25	12.2	774		12	8.3	578		28	1.4	
	26	12.3	780		13	8.1	570		29	1.4	
	27	12.2	774		14	7.9	562		30	1.8	
	28	12.1	769		15	7.9	562	Oct.	1	2.0	
	29	12.0	764		16	7.7	554		2	1.9	
	30	12.0	764		17	7.4	541		3	1.8	
May	1	11.9	758		18	7.1	525		4	1.4	
	2	11.9	758		19	6.7	503		5	1.1	
	3	12.0	764		20	6.3	483		6	1.2	
	4	11.9	758		21	5.6	451		7	2.1	
	5	11.9	758		22	4.9	420		8	1.8	
	6	12.1	769		23	4.3	393		9	1.6	
	7	12.1	769		24	3.9	374		10	1.4	
	8	12.3	780		25	3.7	365		11	1.7	
	9	12.2	774		26	3.4	351		12	2.0	
	10	12.2	774		27	3.3	347		13	2.2	
	11	12.3	780		28	3.2	342		14	2.2	
	12	12.2	774		29	3.3	347		15	2.4	
	13	12.1	769		30	3.4	351		16	2.5	
	14	12.2	774		31	3.4	351		17	2.7	
	15	12.2	774	Aug.	1	3.9	374		18	2.75	

Table showing daily discharge of Mississippi River at Carrollton, La., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1881.			1882.			1882.		
Oct. 19	2.75	322	Jan. 4	9.9	650	Mar. 23	14.65	904
20	2.75	322	5	10.0	661	24	14.65	904
21	2.85	327	6	10.4	681	25	14.8	912
22	2.9	329	7	10.7	696	26	14.8	912
23	2.9	329	8	10.9	706	27	14.95	921
24	3.0	333	9	11.1	716	28	14.9	918
25	2.9	329	10	11.2	721	29	14.75	909
26	2.9	329	11	11.2	721	30	14.65	904
27	3.0	333	12	11.2	721	31	14.6	901
28	3.5	356	13	11.2	721	Apr. 1	14.6	901
29	4.0	379	14	11.3	726	2	14.65	904
30	4.4	397	15	11.3	726	3	14.6	901
31	4.1	383	16	11.4	731	4	14.6	901
Nov. 1	4.1	383	17	11.7	747	5	14.6	901
2	4.2	388	18	11.6	742	6	14.6	901
3	4.2	388	19	11.7	747	7	14.4	890
4	4.3	393	20	11.8	753	8	14.4	890
5	4.4	397	21	12.1	769	9	14.2	879
6	4.5	402	22	12.2	774	10	14.1	874
7	4.9	420	23	12.3	780	11	14.1	874
8	4.8	415	24	12.3	780	12	14.2	879
9	4.8	415	25	12.5	790	13	14.3	884
10	4.8	415	26	12.4	785	14	14.15	876
11	5.0	424	27	12.3	780	15	14.15	876
12	5.2	433	28	12.5	790	16	14.1	874
13	5.2	433	29	12.6	795	17	14.0	869
14	5.3	438	30	12.7	800	18	14.0	869
15	5.3	438	31	12.7	800	19	13.9	864
16	5.45	444	Feb. 1	12.7	800	20	13.9	864
17	5.7	455	2	12.7	800	21	13.75	855
18	5.8	460	3	12.85	807	22	13.9	864
19	5.8	460	4	12.8	805	23	13.7	853
20	6.2	478	5	12.7	800	24	13.6	848
21	6.2	478	6	12.7	800	25	13.5	842
22	6.7	503	7	12.8	805	26	13.5	842
23	7.2	530	8	12.9	810	27	13.45	839
24	7.4	541	9	13.0	816	28	13.45	839
25	7.6	550	10	12.9	810	29	13.6	848
26	7.8	558	11	13.0	816	30	13.5	842
27	8.1	570	12	13.0	816	May 1	13.45	839
28	8.3	578	13	13.1	821	2	13.4	836
29	8.6	591	14	13.1	821	3	13.3	831
30	8.9	606	15	13.2	826	4	13.2	826
Dec. 1	9.0	611	16	13.2	826	5	13.2	826
2	9.2	621	17	13.2	826	6	13.2	826
3	9.4	631	18	13.3	831	7	13.1	821
4	9.4	631	19	13.4	836	8	13.2	826
5	9.5	636	20	13.4	836	9	13.1	821
6	9.7	646	21	13.5	842	10	13.1	821
7	9.7	646	22	13.4	836	11	13.2	826
8	9.8	651	23	13.4	836	12	13.0	816
9	9.9	656	24	13.4	836	13	12.9	810
10	9.9	656	25	13.6	848	14	12.9	810
11	9.8	651	26	13.7	853	15	12.9	810
12	9.8	651	27	13.8	858	16	12.8	805
13	9.6	641	28	14.0	869	17	12.7	800
14	9.5	636	Mar. 1	14.0	869	18	12.8	805
15	8.9	606	2	14.0	869	19	12.7	800
16	8.7	596	3	14.1	874	20	12.8	805
17	8.4	582	4	14.1	874	21	12.8	805
18	8.2	574	5	14.2	879	22	12.8	805
19	7.8	558	6	14.3	884	23	12.7	800
20	7.5	540	7	14.4	890	24	12.8	805
21	7.2	530	8	14.6	901	25	12.8	805
22	6.8	508	9	14.7	907	26	12.8	805
23	6.5	492	10	14.6	901	27	12.8	805
24	6.2	478	11	14.7	907	28	12.8	805
25	6.3	483	12	14.8	912	29	12.7	800
26	6.5	492	13	14.75	909	30	12.7	800
27	6.5	492	14	14.7	907	31	12.6	795
28	6.9	514	15	14.75	909	June 1	12.6	795
29	7.3	536	16	14.8	912	2	12.5	790
30	7.5	546	17	14.8	912	3	12.5	790
31	8.0	566	18	14.9	918	4	12.4	785
1882.			19	14.8	912	5	12.4	785
Jan. 1	8.5	586	20	14.9	918	6	12.4	785
2	8.9	606	21	14.9	918	7	12.5	790
3	9.5	636	22	14.8	912	8	12.7	800

Table showing daily discharge of Mississippi River at Carro

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1881.			1881.		
Feb. 27	12.3	780	May 16	12.1	769
28	12.1	769	17	12.0	764
Mar. 1	12.2	774	18	12.1	769
2	12.0	764	19	12.1	769
3	12.1	769	20	12.1	769
4	12.2	774	21	12.25	777
5	12.2	774	22	12.3	[illegible]
6	12.1	769	23	12.3	[illegible]
7	12.2	774	24	12.3	[illegible]
8	12.0	764	25	12.3	[illegible]
9	12.0	764	26	12.4	[illegible]
10	12.2	774	27	12.3	[illegible]
11	12.3	780	28	12.3	[illegible]
12	12.4	785	29	12.3	[illegible]
13	12.3	780	30	12.4	[illegible]
14	12.4	785	31	12.3	[illegible]
15	12.5	790	June 1	12.3	[illegible]
16	12.5	790	2	12.2	[illegible]
17	12.4	785	3	12.2	[illegible]
18	12.3	780	4	12.2	[illegible]
19	12.3	780	5	12.2	[illegible]
20	12.2	774	6	12.2	[illegible]
21	12.3	780	7	12.2	[illegible]
22	11.9	758	8	12.2	[illegible]
23	12.1	769	9	12.0	[illegible]
24	12.1	769	10	12.0	[illegible]
25	12.1	769	11	11.9	[illegible]
26	12.2	774	12	11.6	[illegible]
27	12.2	774	13	11.3	[illegible]
28	12.3	780	14	11.1	[illegible]
29	12.4	785	15	10.9	[illegible]
30	12.25	777	16	10.8	[illegible]
31	12.2	774	17	10.7	[illegible]
Apr. 1	12.2	774	18	10.5	[illegible]
2	12.2	774	19	10.3	[illegible]
3	12.2	774	20	10.2	[illegible]
4	12.3	780	21	10.1	[illegible]
5	12.3	780	22	10.0	[illegible]
6	12.3	780	23	9.75	[illegible]
7	12.3	780	24	9.6	[illegible]
8	12.4	785	25	9.6	[illegible]
9	12.4	785	26	[illegible]	[illegible]
10	12.4	785	27	[illegible]	[illegible]
11	12.4	785	28	[illegible]	[illegible]
12	12.55	792	29	[illegible]	342
13	12.5	790	30	[illegible]	334
14	12.3	780	July 1	[illegible]	343
15	12.3	780	2	[illegible]	342
16	12.2	774	3	[illegible]	328
17	12.0	764	4	[illegible]	329
18	12.1	769	5	[illegible]	316
19	12.1	769	6	[illegible]	308
20	12.0	764	7	[illegible]	308
21	12.1	769	8	[illegible]	308
22	12.1	769	9	[illegible]	300
23	12.2	774	10	[illegible]	288
24	12.4	785	11	[illegible]	272
25	12.2	774	12	[illegible]	267
26	12.3	780	13	[illegible]	272
27	12.2	774	14	[illegible]	272
28	12.1	769	15	[illegible]	276
29	12.0	764	16	[illegible]	284
30	12.0	764	17	[illegible]	280
May 1	11.9	758	18	[illegible]	288
2	11.9	758	19	[illegible]	300
3	12.0	764	20	[illegible]	292
4	11.9	758	21	[illegible]	280
5	11.9	758	22	[illegible]	272
6	12.1	769	23	[illegible]	261
7	12.1	769	24	[illegible]	[illegible]
8	12.3	780	25	[illegible]	[illegible]
9	12.2	774	26	[illegible]	[illegible]
10	12.2	774	27	[illegible]	[illegible]
11	12.3	780	28	[illegible]	[illegible]
12	12.2	774	29	[illegible]	[illegible]
13	12.1	769	30	[illegible]	[illegible]
14	12.2	774	31	[illegible]	[illegible]
15	12.2	774	Aug. 1	[illegible]	[illegible]

Widths between high-water banks.

No.	Locality.	M. R. C., 1883.	H. & A., 1851.	Remarks.
		Feet.	*Feet.*	
....	Cole Creek Point	1,935	*2,350	*Locality uncert
....	Natchez	4,132	*4,540	*Do.
....	Ellis Cliffs	1,935	*3,250	*Do.
....	Routh's Point	3,792	3,880	
....	Mouth of Red River	4,231	3,500	
....	4,000 feet below Red River	4,329	3,600	
....	8,000 feet below Red River	3,575	3,700	
....	12,000 feet below Red River	3,936	3,000	
....	Raccourci, upper end	4,592	2,400	
....	Raccourci, lower end	3,280	2,400	
....	Tunica Bend	3,476	*3,320	*Ellet's report.
1	Baton Rouge, Arsenal	3,181	2,960	
2	Baton Rouge, State-House	2,657	2,850	
3	4,000 feet below State-House	2,460	2,200	
4	8,000 feet below State-House	2,591	2,650	
5	12,000 feet below State-House	2,813	3,025	
6	16,000 feet below State-House	3,313	2,400	
7	20,000 feet below State-House	2,859	3,100	
8	24,000 feet below State-House	3,509	3,400	
9	28,000 feet below State-House	3,673	3,000	
10	32,000 feet below State-House	3,313	2,650	
11	36,000 feet below State-House	3,575	3,250	
12	40,000 feet below State-House	3,286	3,400	
13	44,000 feet below State-House	2,574	2,250	
14	48,000 feet below State-House	2,492	2,250	
15	52,000 feet below State-House	2,771	2,475	
16	56,000 feet below State-House	2,788	2,550	
17	60,000 feet below State-House	2,624	2,500	
18	64,000 feet below State-House	2,820	2,450	
19	68,000 feet below State-House	3,903	3,700	
20	Mouth of Bayou Manchac	3,608	2,950	
21	4,000 feet below Bayou Manchac	2,558	2,400	
22	8,000 feet below Bayou Manchac	2,377	2,300	
23	12,000 feet below Bayou Manchac	2,460	2,450	
24	16,000 feet below Bayou Manchac	3,542	3,250	
25	20,000 feet below Bayou Manchac	3,345	2,900	
26	24,000 feet below Bayou Manchac	2,705	2,400	
27	Mouth of Plaquemine Bayou	2,132	2,700	
28	4,000 feet below Plaquemine Bayou	2,952	2,750	
29	8,000 feet below Plaquemine Bayou	2,689	2,575	
30	12,000 feet below Plaquemine Bayou	2,344	2,930	
31	16,000 feet below Plaquemine Bayou	2,066	2,930	
32	20,000 feet below Plaquemine Bayou	3,063	2,930	
33	24,000 feet below Plaquemine Bayou	4,296	4,400	
34	28,000 feet below Plaquemine Bayou	3,542	3,500	
35	32,000 feet below Plaquemine Bayou	2,591	2,500	
36	36,000 feet below Plaquemine Bayou	2,408	2,400	
37	40,000 feet below Plaquemine Bayou	3,033	2,850	
38	44,000 feet below Plaquemine Bayou	2,722	2,700	
39	48,000 feet below Plaquemine Bayou	2,755	2,450	
40	52,000 feet below Plaquemine Bayou	2,591	2,450	
41	56,000 feet below Plaquemine Bayou	2,635	2,800	
42	Bayou Goula	4,165	3,750	
43	4,000 feet below Bayou Goula	3,444	3,250	
44	8,000 feet below Bayou Goula	2,814	2,650	
45	12,000 feet below Bayou Goula	2,099	2,650	
46	16,000 feet below Bayou Goula	2,460	2,500	
47	20,000 feet below Bayou Goula	2,476	2,250	
48	24,000 feet below Bayou Goula	2,460	2,400	
49	28,000 feet below Bayou Goula	2,624	2,500	
50	32,000 feet below Bayou Goula	3,394	3,100	
51	36,000 feet below Bayou Goula	3,903	3,500	
52	40,000 feet below Bayou Goula	3,936	3,700	
53	Opposite Claiborne Isle	2,952	3,400	
54	4,000 feet below Claiborne Isle	3,066	2,450	
55	8,000 feet below Claiborne Isle	2,919	2,800	
56	12,000 feet below Claiborne Isle	3,181	3,100	
57	16,000 feet below Claiborne Isle	2,853	3,000	
58	20,000 feet below Claiborne Isle	2,682	2,500	
59	Ashland plantation	2,682	2,550	
60	4,000 feet below plantation	2,640	3,550	
61	8,000 feet below plantation	2,939	3,500	
62	12,000 feet below plantation	3,280	3,000	
63	16,000 feet below plantation	3,627	3,000	
64	20,000 feet below plantation	2,657	2,450	
65	24,000 feet below plantation	2,296	2,600	
66	28,000 feet below plantation	2,705	2,700	
67	32,000 feet below plantation	2,657	2,600	
68	Donaldsonville	2,952	3,300	
	Mean of 68 sections	2,984	2,835	

O[illegible]phreys and Abbot Report, the elevation of the high water of 1851 ab[illegible]ven as 49.5 feet. Correcting this by 0.8 foot, the difference in the tw[illegible] of the Hampson bench above mean tide, we have, 48.7 feet as the heig[illegible] surface at Red River Landing; or 56.7 feet above Memphis datum plane, [illegible] feet below the high water of 1858 at Memphis, Tenn., or 190.84 feet below [illegible] of United States Engineers' gauge at that point. It is 8.1 feet above the mean level of the Gulf.

No comparison of the benches at Red River or Baton Rouge could be made. Chief of Engineer's Report, 1872, page 433, states that "no vestige of the old United States bench remains." Report of 1873, page 522, gives zero of Baton Rouge gauge as 0.90 foot lower than theDelta Survey gauge, but the records do not show whether gague has since been changed or not. The comparisons, therefore, depend, for the Delta Survey, on a double line of levels from Carrollton to Baton Rouge, and a single line "run with the greatest care" from the latter point to Red River Landing, and for the survey of 1883 on a line of "precise levels" made by the United States Coast and Geodetic Survey; these two surveys being connected only at the lower end, on what is known as Hampson's bench-mark. It is probable that the discrepancy at Red River Landing is quite small, as the top of the levee, according to the Delta Survey, is 59 feet above the Memphis datum, and the survey of 1883 gives it as 58 to 59 feet above same datum.

Sections in th[illegible]onaldsonville.

The next reliable sections with which [illegible]sons can be made are in the vicinity of Donaldsonville. The sou[illegible]y the United States Coast and Geodetic Survey during the latt[illegible]he first half of 1881.

Comparison of sections between Plaquemine and Donaldsonville.

Section.		Locality.	Areas.		Maximum depth.		Difference of areas.	Reading of Baton Rouge gauge.			
1881.	1883.		1881.	1883.	1881.	1883.		Date.	Readings.	Date.	Readings.
			Sq. ft.	*Sq. ft.*	*Feet.*	*Feet.*	*Square feet.*	1881.		1883.	
O″	168	2½ miles below Plaquemine	133,825	131,000	163	150	− 2,825	(a)	....	Mar. 1	29.2
J″	178	Arcadia Landing	109,250	100,250	151	132	− 9,000	(a)	....	Mar. 2	29.4
J″	179	Just below Arcadia	120,750	97,500	105	113	−23,250	(a)	....	Mar. 2	29.4
H″	181	1 mile below Arcadia	119,250	113,250	96	98	− 6,000	(a)	....	Mar. 2	29.4
G″	182	1½ miles below Arcadia	115,750	108,500	87	89	− 7,250	(a)	....	Mar. 2	29.4
F″	184	½ mile above Brown's Landing	124,750	128,125	102	90	+ 3,375	(a)	....	Mar. 9	30.4
E″	186	Near Brown's Landing	152,000	130,000	160	177	−22,000	(a)	....	Mar. 10	30.4
D″	188	½ mile below Brown's Landing	152,250	147,500	169	146	− 4,750	(a)	....	Mar. 10	30.4
C″	S. L. 21	1 mile below Brown's Landing	125,000	144,000	135	137	+19,000	(a)	....	Mar. 8	30.4
A″	194	1 mile above Dunboine Landing	118,825	133,000	105	104	+14,175	(a)	....	Mar. 8	30.4
X′	A. 196	Ophelia Landing	126,500	108,325	97	90	−18,175	(a)	....	Mar. 10	30.4
V′	S. L. 22	½ mile above Bayou Goula	132,000	105,570	133	115	−26,430	(a)	....	Mar. 10	30.4
T′	200	½ mile below Bayou Goula	113,500	112,925	141	131	− 575	(a)	....	Mar. 13	30.5
S′	201	1 mile below Bayou Goula	112,175	114,250	131	138	+ 2,075	(a)	....	Mar. 13	30.5
P′	S. L. 23	1½ miles above Belle Grove	148,800	163,750	158	156	+14,950	(a)	....	Mar. 13	30.5
O′	206	½ mile above Belle Grove	112,250	117,625	105	109	+ 5,375	(a)	....	Mar. 14	30.5
N′	207	Just above Belle Grove	124,825	139,500	110	116	+14,675	(a)	....	Mar. 14	30.5
M′	209	Just below Belle Grove	119,250	109,150	97	97	−10,100	(a)	....	Mar. 14	30.5
J′	213	Just above Hard Times	113,675	93,075	74	76	−20,600	Apr. 9	30.0	Mar. 12	30.4
H′	216	1 mile below Hard Times	108,500	97,575	144	106	−10,925	Apr. 5	30.0	Mar. 12	30.4
F′	218	½ mile above Southwood	109,250	124,500	97	126	+ 5,250	Mar. 23	29.4	Mar. 12	30.4
E′	219	Just above Southwood	130,250	145,570	128	144	+15,320	Mar. 22	29.4	Mar. 14	30.5
C′	223	1 mile below Southwood	116,075	120,150	115	131	+ 4,075	Mar. 10	29.6	Mar. 15	30.6
A′	225	1½ miles below Southwood	118,750	127,250	92	103	+ 8,500	Mar. 8	28.8	Mar. 15	30.6
X	228	1 mile below Woodstock	109,750	110,000	90	92	+ 250	Feb. 18	24.5	Mar. 15	30.7
V	230	Just above Ashland	110,125	106,125	78	79	− 4,000	Feb. 12	24.4	Mar. 15	30.7
T	223	1 mile below Ashland	124,375	127,750	88	107	+ 3,375	Feb. 10	24.4	Mar. 16	30.8
P	S. L. 27	½ mile above Ascension	120,875	152,125	104	110	+31,250	Jan. 21	8.0	Mar. 16	30.8
O	239	Just above Ascension	119,625	119,000	99	105	− 625	Jan. 15	8.0	Mar. 16	30.8
M	241	½ mile below ascension	148,575	161,375	153	151	+12,800	Jan. 6	13.9	Mar. 16	30.8
								1880.			
K	S. L. 28	1½ miles above Donaldsonville	119,500	120,250	118	115	+ 750	Dec. 28	19.5	Mar. 16	30.8
J	247	1 mile above Donaldsonville	120,500	146,000	103	112	+25,500	Dec. 17	20.1	Mar. 16	30.8

a Soundings taken in April and May, dates not known. Baton Rouge gauge ranges between 29.9 and 29.8.

	Square feet.
Mean area of sections in 1881	122,836
Mean area of sections in 1883	123,593
Difference of means	757

Depths are referred to the plane of 1883.

Thirty-two sections which are identical with or come very near the sections of 1883 have been plotted and are shown on Plates 9, 10, and 11.

The sections of the Coast Survey and Geodetic Survey are copied from tracings (S. 48) on file in this office. The soundings there shown were reduced to the "average low water of the year" during which they were taken. The stage of the river when the soundings were made was but a little below the high water of 1881. A comparison of the sections is given in the above table, the area of the sections being measured below the lowest water surface, or that given by the United States Coast and Geodetic Survey sections. The sections were plotted and the areas measured with a planimeter by Assistant H. B. Wood.

Very respectfully, your obedient servant,

J. A. OCKERSON,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

APPENDIX H.

REPORT OF CAPTAIN CLINTON B. SEARS, CORPS OF ENGINEERS, UNITED STATES ARMY, EXECUTIVE OFFICER, DEPARTMENT OF CONSTRUCTION.

DEPARTMENT OF CONSTRUCTION,
Saint Louis, Mo., November 5, 1883.

COLONEL: In accordance with your circular letter of September 6, 1883, I have the honor to submit the following report of operations performed under my immediate supervision as executive officer, construction department, Mississippi River Commission, since the date of my last annual report, which was brought up to December 1, 1882.

My office has been fully employed during the past eleven months, in the construction of the floating plant, recommended by the Commission, and approved by the honorable the Secretary of War, in its distribution to the various works; in the charter of steamers; in the purchase and supply of stone, wire, coal, subsistence stores, and other material required on the several reaches; in the care of the fleet at Cairo, consisting of coal and floating plant not in use; in the repair of boats and barges, and in the management of the general service steamers.

The general system of purchase and supply was outlined in my last report, and need not be repeated here. This system, as there stated, has been continued. Special freight rates have been secured from commercial steamers and from the railroads, and shipments have been made by one or the other, as happened to be more favorable at the time, whenever the shipment has been so small as not to justify bringing one of our steamers to Saint Louis.

During the winter, when ice has closed the river down to Cairo, supplies have been shipped by rail to Cairo, and hence by our steamers. The steamers Mississippi and Etheridge have been kept in almost constant use towing our barges and other plant. In August the Etheridge, in bringing down a tow from Louisville, got aground at Flint Island bar, in the Ohio River, and was, after some difficulty, pulled off into deeper water above the bar. As there appeared to be no prospect of getting her down for some weeks, owing to low water, she was laid up at Louisville, under charge of watchmen, and her crew transferred to the steamer Jack Frost. Her tow was taken down by the Reindeer, a small light-draught boat, chartered temporarily for the purpose. October 16, the Etheridge reached Cairo in tow of the Minnetonka, and was put in commission immediately. August 7, the steamer John Dippold, a powerful boat belonging to the Mississippi Valley Transportation Company, was chartered for the general service at $50 per day, for two weeks, or longer, if necessary. She was kept in constant use until October 7, when she was turned in to the owners. Another large steamer, the Jack Frost, was chartered for the general service, September 15, 1883, at $50 per day, for such time as the Etheridge might be laid up. She was surrendered to her owners October 16, 1883, and the same day the new tow-boat, Minnetonka, was chartered for three months, at $60 a day, with the privilege of pur-

5,000, less charter money paid. At present, therefore, we have in the gen-
e, three steamers, two belonging to the United States and one chartered.
e ten months ending October 31, 1883, the Mississippi has moved 489
: various distances, amounting to one piece moved 113,177 miles at a cost of
per mile. Her average daily expenses while doing this work have been
is includes fuel, pay, and subsistence of crew, and supplies and other run-
nses, but does not include interest on her cost, nor the cost of repairs. She
nade several trips with the Commission or the construction committee,
e running expenses of which have been paid by the secretary of the Com-
ut of the appropriation for Mississippi River Commission.
eridge during the eleven months has moved 377 pieces over various distances,
g to one piece moved 104,861 miles, at a cost of 22 cents per mile. Her av-
y expenses have been $68.84½.
pold, while under charter, moved 139 pieces over various distances, amount-
piece moved 37,930 miles, at a cost of 35.3 cents per mile. Her daily ex-
cluding charter, averaged $212.76. She was in service 63 days. The Jack
ile under charter, moved 69 pieces, amounting to one piece moved 10,359
a cost of 49.4 cents per mile. Her daily expenses, including charter, aver-
.12½. She was under charter 31 days. These two steamers would have shown
ter results, from an economical point of view, had circumstances permitted
e worked them up to their full capacities. For reasons to be hereafter ex-
his was impracticable.
nnetonka has not been in service sufficiently long to enable me to report
be a fair average as to her daily expenses. She was built for our work, and
as been left undone by her owners to make her an acceptable boat for that
She is fully equipped in every respect for towing. My original arrange-
h her owners was to charter her for six months, but owing to their delay in
g her, I cut this down to three months with the privilege of a renewal, if
Summing up the above, I find that our general-service steamers have aver-
5.78¾, per day each, as to running expenses, and have moved 1,074 pieces
distances, or one piece 266,327 miles, at an average cost of 33.15 cents per
timating each piece at 100 tons (a low estimate) will make the cost per ton
one-third cent. Had we had this towing done by commercial steamers it
ve cost about two-fifths cent per ton mile, and we would have been subjected
vexatious and expensive delays.
mer captains have had great trouble in keeping efficient crews, especially
e sickly season. Government boats pay no hospital dues, and when men
em they forfeit their right to treatment and care at the marine hospitals,
g the benefit of dues previously paid when on commercial steamers. The
ner and fall seasons have been very unhealthy on the lower river, and sev-
our boats have been disabled for want of effective crews.
I earnestly recommend that the Commission take some action towards secur-
r through the Treasury Department or by Congress, some remedy for this
seems to me but proper that men employed on United States civil vessels
ve the right to hospital treatment. Practically this is at present denied
whether proper or not, it would certainly add to the efficiency of our
ervice if such medical aid could be given.
artered steamer Success, in use on Lake Providence Reach, was returned to
rs April 20, 1883, not having proved satisfactory.
y 1, 1883, I chartered the steamer Graham for six months, at $15 a day, for
e Memphis Reach. July 1 this charter was extended three months with the
of six months. She is still under charter.
y 2, 1883, I bought the steamer Charlie De Pauw for $17,404, she having
erself a valuable and efficient boat. She was kept in constant use on Lake
ce Reach until August, when she broke her shaft. She was sent to Saint
a new shaft and a general overhauling. After being thoroughly repaired
y repainted, her name was changed to the Vidalia, and she was returned to
Providence Reach, where she is doing good work.
, 1883, I chartered the steamer J. C. Fisher, for the Lake Providence Reach,
r day for six months. Though her charter has expired we still retain her,
ct to have use for her until navigation closes.
, 1883, I chartered the steamer Little Eagle No. 2, for use on the Plum Point
r seven months, at $17.50 per day.
9, 1883, I chartered the steamer Pearl, for use on Lake Providence Reach,
months, at $17.50 per day.
nber 2, 1883, I chartered the steamer Little Andy Fulton, for use on Lake
ce Reach, at $30 a day for three months.
and launch have been purchased for use at New Orleans, and another launch
n Plum Point Reach.

The Commission has, therefore, the following steamers in commission:

Belonging to the United States:

Mississippi, Etheridge: Steam tow-boats for general service.
Pete Kirns, Itasca: Steam tow-boats in use at Plum Point.
Vidalia: Steam tow-boat in use at Lake Providence.
Mineola: Steam launch sunk at Plum Point.
Nellie: Steam launch in use at Lake Providence.
Titania: Steam launch in use at Plum Point.
Alaska: Steam launch in use at New Orleans.
Tilda: Steam tug in use at New Orleans.

Chartered:

Minnetonka: Steam tow-boat in general service.
Little Eagle No. 2: Steam tow-boat in use at Plum Point.
Graham: Steam tow-boat in use at Memphis.
J. C. Fisher: Steam tow-boat in use at Lake Providence.
Pearl: Steam tow-boat in use at Lake Providence.
Little Andy Fulton: Steam tow-boat in use at Lake Providence.

In all, eleven steamers, one tug, and four launches; six of the steamers being un[der] charter.

The most difficult problem to solve has been the supply of stone to the works; a[nd] so far, owing to a number of circumstances beyond my control, I have been unabl[e to] keep up the supply in a manner satisfactory to myself or to the district officers. [The] entire absence of suitable quarries between Cairo and Yazoo River, necessitates [the] stone being brought from up the Ohio River; or, from Chester, on the Mississi[ppi] River. At the time when stone is needed most, navigation is in the worst conditi[on] due to low water or running ice in the Ohio, and low water or solid and running [ice] in the Mississippi.

Last winter the supply was entirely inadequate to the demand, owing to [the] danger to our barges from the running ice in the Ohio, and from the difficulty in lo[ad]ing barges at the quarries, due to bad weather and sleet.

During the summer and fall, navigation on the Ohio River has been so bad tha[t I] have taken off our boats, and have made arrangements with the contractor to rece[ive] and deliver our barges at Cairo, he using a small light-draught boat. It has a[lso] been dangerous to load our barges to their full capacities, owing to low water.

For several weeks I could not get barges up to the Ohio River quarries with ev[en] a small tow-boat. Early in the low-water season I arranged to get stone at Chest[er], Ill., but the loading facilities are limited. Another cause of failure in supply has be[en] want of barges. This has arisen from two causes. The district officers of two d[is]tricts have been pressed for barges, owing to the scattered condition of their part[s] and the long towage of brush, and have had to utilize whatever empty general-se[rv]ice barges were at hand. In this way there resulted a large accumulation of gener[al-] service barges at the works, leaving the quarries without any for some two weeks.

Again, our barges necessarily built out of green timber and sent down to a wa[rm] climate in the hottest season soon began to need recalking, so that a number of bar[ges] have been unavailable, undergoing repair.

After getting a few made up, low water in the Mississippi has made it both diffic[ult] and dangerous to get the tow down, and we have lost two barges and their loads. [I] [illegible] one barge and its load at Old Hen, just above Hopefield. T[his] condition of affairs has prevented the boats from being worked to their full capaciti[es]. During high water there is no trouble in getting stone loaded and towed down, b[ut] this is the time when there is least demand. In March I began the storing of sto[ne] on the bank at [illegible], but had accumulated only some 3,000 yards when I had [to] take it all for use at Plum Point. In August I contracted for the delivery of 20,0[00] cubic yards on the bank at Arkansas City for the use of the Lake Providence Rea[ch]. Up to October 31 there has been so delivered some 6,000 cubic yards. I have sen[t a] party down to load this on barges.

The only way to insure a full supply of stone to the works during the busiest s[ea]son is to begin in January of each year the accumulation of stone on the bank [at] two or more points, such as [illegible] and Arkansas City: this to continue until t[he] demand from the works increases so as to take all the quarries and towage service o[f] supply. The stone so stored can then be taken, from time to time, as the direct supp[ly] fails during low water. This method, at best, is clumsy and expensive, but I see [no] other way less expensive and equally sure. This cannot be done, however, the co[m]ing season, unless an appropriation is made immediately available. We should ha[ve] by August 1, 1884, at each of these places, some 20,000 yards at least. Since Nove[m]ber 30, 1882, I have supplied to the works some 73,719 cubic yards of stone; 459 t[ons] of galvanized steel wire, and several hundred tons of miscellaneous freight in [the] shape of provisions, rope, lumber, iron, and other supplies. Our contracts requir[e us] to take about 26,323 cubic yards of stone in addition to that already received. I s[ub]mit herewith, marked A, a table showing the description, first cost, and distribut[ion] of the floating plant bought by me since November 30, 1882:

ynopsis is herewith submitted, viz:

team tow-boat	$17,404 00
Steam tug	5,000 00
Steam launch	3,000 00
Mattress-boats	40,360 00
Screen-boats	6,000 00
Quarter-boats	34,463 00
Barges	275,127 40
Pile-drivers	142,661 76
Machine-shop boats (balance)	9,871 25
Pumping-boat	1,500 00
Whitehall boats	339 00
skiffs	2,126 00
tfit of plant	17,246 28
scellaneous (anchors, hoisting-engines, boilers, electric-light outfits, pump and derrick)	9,988 78
ope	23,114 50
	588,201 97

Of this amount $142,983.68 was for plant now in use for the general service. An itemized statement of my expenditures from December 1, 1882, to October 31, 1883, accompanies this report, and is marked B.

The following is a classified statement of said expenditure:

SCHEDULE OF EXPENDITURES BY CAPTAIN CLINTON B. SEARS, EXECUTIVE OFFICER, CONSTRUCTION DEPARTMENT, MISSISSIPPI RIVER COMMISSION, ON ACCOUNT OF APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, FROM NOVEMBER 30, 1882, TO OCTOBER 31, 1883.

General service.

Office:		
Pay-roll	$8,469 83	
Furniture and office outfit	387 45	
Stationery	371 12	
Transportation and traveling expenses	1,400 85	
Ice and water	79 91	
Rent and repairs	679 70	
Gas and fuel	170 97	
Telegraphing	344 75	
Mileage	1,289 06	
Fuel for Captain Sears	160 48	
		$13,354 12
COAL FLEET.		
Material and supplies	$369 57	
Plant and outfit	336 93	
Transportation	174 84	
Labor	16 00	
Ice	7 59	
Care of public property	4,074 00	
Repairs	30 33	
		5,009 26
STONE DEPOT.		
Inspection and administration	$13 50	
Material and supplies	338 06	
Plant and outfit	1,453 90	
Transportation	14 35	
Labor	2,681 00	
Subsistence	54 00	
		4,554 81
STEAMER MISSISSIPPI.		
Office expenses	$46 51	
Material and supplies	2,133 99	
Fuel	33 21	
Plant and outfit	224 17	
Transportation and steamer expenses	12,832 85	
Repairs	1,517 42	
Labor	694 59	
Subsistence	5,061 36	
Care of public property	221 50	
		22,765 60

STEAMER EMMA ETHERIDGE.

[illegible]	$65 31	
…ies	2,172 00	
[illegible]	1,433 50	
…l steamer expenses	12,952 72	
[illegible]	1,003 94	
[illegible]	498 20	
[illegible]	3,726 74	
…ic property	207 99	
		$22,06

STEAMER JOHN DIPPOLD.

Office expenses	$6 40	
Material and supplies	1,199 20	
Fuel	3,665 60	
Repairs	14 35	
Transportation and steamer expenses	6,372 65	
Labor	40 75	
Subsistence	1,208 60	
		12,50

STEAMER JACK FROST.

Office expenses	$12 07	
Material and supplies	1,739 02	
Plant and outfit	19 25	
Fuel	1,131 19	
Transportation and steamer expenses	3,340 42	
Labor	10 00	
Subsistence	564 01	
		6,80

STEAMER REINDEER.

Material and supplies	$3 92	
Fuel	133 50	
Labor	8 00	
Transportation and steamer expenses	459 98	
Subsistence	79 05	
		68

STEAMER MINNETONKA.

Office expenses	$10 21	
Material and supplies	360 09	
Transportation and steamer expenses	866 34	
Fuel	427 60	
Labor	23 92	
Subsistence	302 58	
		1,990
Total account of general service		89,732

FOR NEW MADRID REACH.

Inspection and administration	$461 07	
Office expenses	3 00	
Plant and outfit	187,195 63	
Transportation	1,870 66	
Material and supplies	686 18	
Labor	20 00	
Repairs to plant	9 50	
Care of public property	18 50	
		190,264

FOR PLUM POINT REACH.

Inspection and administration	$1,383 42	
Office expenses	200 25	
Material and supplies	64,662 67	
Fuel	1,765 26	
Plant and outfit	88,596 73	
Transportation	5,674 28	
Repairs to plant	6,989 03	
Labor	401 49	
Subsistence	32,191 86	
Care of public property	622 00	
		202,486

FOR MEMPHIS REACH.

d administration	$1,250 16	
es	2 00	
supplies	12,956 21	
tfit	121,791 54	
on	5,712 24	
ant	407 45	
	115 50	
	1,277 92	
ic property	260 65	
		$143,773 67

FOR LAKE PROVIDENCE REACH.

nd administration	$1,934 49	
ses	13 10	
l supplies	35,855 35	
	844 00	
itfit	144,152 84	
ion	13,064 08	
lant	2,734 68	
	432 54	
	27,257 94	
lic property	586 46	
		226,875 48
account on improving Mississippi River		853,133 57

F EXPENDITURES ON ACCOUNT OF APPROPRIATION FOR IMPROVING HAR- NEW ORLEANS, LA., FROM NOVEMBER 30, 1882, TO OCTOBER 31, 1883.

nd administration	$299 67	
ses	10 00	
d supplies	3,290 03	
utfit	24,460 97	
ion	677 50	
lant	159 30	
	168 97	
	497 45	
lic property	6 00	
		29,569 89

OF EXPENDITURES ON ACCOUNT OF APPROPRIATION FOR IMPROVING RED RIVER, LOUISIANA, FROM NOVEMBER 30, 1882, TO OCTOBER 31, 1883.

ses	$10 00	
d supplies	277 15	
	614 62	
utfit	4,524 00	
	56 37	
	910 60	
ion	26 00	
lic property	10 00	
		6,428 74

CLASSIFIED SUMMARY.

or:		
nd outfit	$574,189 46	
l and supplies	126,043 44	
ence	73,122 11	
ortation	65,439 76	
to plant	12,866 00	
d gas	8,946 43	
xpenses (including pay-rolls)	8,848 68	
public property	6,007 10	
ion and administration	5,342 31	
	5,167 33	
e	1,289 06	
nd repairs	679 70	
ure and office outfit	387 45	
ery	371 12	
aphing	344 75	
d water	87 50	
		889,132 20

GENERAL SUMMARY.

Improving harbor at New Orleans, La	$29,569 89	
For improving mouth of Red River, Louisiana	6,428 74	
		$35,9
For New Madrid Reach	190,264 54	
For New Madrid Reach, proportion of general service	4,605 84	
		194,8
For Plum Point Reach	202,486 99	
For Plum Point Reach, proportion of general service	38,144 57	
		240,6
For Memphis Reach	143,773 67	
For Memphis Reach, proportion of general service	8,837 91	
		152,6
For Lake Providence Reach	226,875 48	
For Lake Providence Reach, proportion of general service	38,144 57	
		265,0
		889,1

The above amount, $89,732.89, for the general service, has been divided up a the several allotments, as shown in the general summary. Whenever an expend has been specifically for any particular reach, it has, of course, been charged to reach. There have been, however, large expenditures which it has been impos without complicating accounts very seriously, to definitely assign to any parti allotment. These I have divided among the several allotments in proportion to respective amounts, duly considering the service each reach has received.

When towing for Red River and New Orleans has been done by the general se steamers, the necessary expense has been met by assigning sufficient of the vou of said steamers for payment by these appropriations. This method of dividin general service expenses is inaccurate, clumsy, and unsatisfactory, and make accounts very complicated. I would recommend, therefore, that if another appr ation be given, a special allotment be made for the general service, with auth for me to draw on the several allotments for such amounts as cover specific exp tures for the corresponding reaches. I would further recommend that the offic charge of the fourth district purchase all his own supplies except such as he may convenient to have me buy and ship, as stone and coal. New Orleans is a better ket for this district than Saint Louis.

I summit the following financial statement of all funds expended under the co of the Mississippi River Commission to November 1, 1883.

FINANCIAL STATEMENT.

(July 1, 1882, to October 31, 1883.)

NEW MADRID REACH.

	By Captain Sears.	By Captain Knight.	Total
Drawn from Treasury	$207,000 00	$5,500 00	$212,
Expended	204,572 16	4,498 95	209,
Balances in hand, available November 1, 1883	2,427 84	1,001 05	3,

All the allotment, viz, $212,500, has been drawn.

PLUM POINT REACH.

	By Captain Sears.	By Captain Knight.	Total
Balances on hand from previous appropriation, fiscal year ending June 30, 1882	$10,232 11	$12,424 90	$22,
Drawn from Treasury of current appropriation	314,000 00	635,000 00	949,
Total to be accounted for	324,232 11	647,424 90	971,
Expended	298,866 96	561,917 16	860,
Balances in hand	25,365 15	85,507 74	110,

from current appropriation	$1,000,000 00
m Treasury	949,000 00
n Treasury	51,000 00
n hands of disbursing officers	110,872 89
, November 1, 1883	160,872 89

MEMPHIS REACH AND HARBOR.

	By Captain Sears.	By Major Miller.	Total.
m Treasury, &c	$167,000 00	$125,000 00	$292,000 00
	162,379 64	105,890 00	268,269 64
nces in hand	4,620 36	19,110 00	23,730 36

nt from current appropriation	$325,000 00
	292,000 00
in Treasury	33,000 00
in hands of disbursing officers	23,730 36
le November 1, 1883	56,730 36

SURVEY OF HELENA REACH.

by Major Miller	$8,000 00
ed by Major Miller	7,511 29
available November 1, 1883	488 71

e allotment, viz, $8,000, has been drawn.

LAKE PROVIDENCE REACH.

	By Captain Sears.	By Captain Marshall.	Total.
on hand from appropriation for fiscal year June 30, 1882	$10,232 11	$3,341 74	$13,573 85
m Treasury of current appropriation	354,000 00	459,000 00	813,000 00
be accounted for	364,232 11	462,341 74	826,573 85
d	359,531 33	447,714 59	807,245 92
ances in hand	4,700 78	14,627 15	19,327 93

nt from current appropriation	$950,000 00
	813,000 00
in Treasury	137,000 00
in hands of disbursing officers	19,327 93
le November 1, 1883	156,327 93

VICKSBURG HARBOR.

by Captain Marshall	$50,000 00
led by Captain Marshall	44,522 40
in hand	5,477 60
nt from current appropriation	100,000 00
	50,000 00
in Treasury	50,000 00
in hand	5,477 60
le November 1, 1883	55,477 60

NEW ORLEANS HARBOR.

	By Captain Sears.	By Major Stickney.	Total.
Bal[illegible] July 1, 1882, from previous appro-			$144,525 9[illegible]
[illegible]ly 1, 1882		$3,267 91	3,267 9[illegible]
Total to be accounted for		3,267 91	147,793 8[illegible]
Drawn from Treasury	$35,000 00	3,267 91	41,267 9[illegible]
Expended	29,569 89	5,845 01	35,41[illegible]
Balances in hand	5,430 11	−2,577 10	2,853 0[illegible]

Available July 1, 1882	$147,793 81
Drawn	41,267 91
Balance in Treasury[illegible]	106,525 90
Balance in hands o[illegible]	2,853 01
Available November[illegible]	109,378 91

SAI[illegible], FIRST DISTRICT.

Drawn by Captain K[illegible]	$5,000 00
Expended by Captain[illegible]	3,312 91
Balance available No[illegible]	1,687 09

All the allotment, viz, $5,000[illegible]wn.

SAINT FRANCIS R[illegible], SECOND DISTRICT.

Drawn by Major Miller	$4,000 00
Expended by Major Miller	3,212 93
Balance available November 1, 1882	787 07

All the allotment, viz, $4,000, has been drawn.

MOUTH OF RED RIVER.

	By Captain Miller.	By Captain Sears.	By Major Stickney.	Total.
Drawn from the Treasury from previous appropriations	$[illegible]	$5,000 00	*$25,000 00	$37,812 40
Expended	[illegible]	4,428 74	37,883 46	51,970 0[illegible]
Balances in hand	[illegible]	571 26	−12,883 46	−14,158 26

* Drawn [illegible] by Major Stickney September 30, 1882.

Available June 30, 1882	$90,812 40
Drawn	37,812 40
Balance in Treasury	53,000 00
Balance in hands of disbursing officers	−14,158 26
Available November 1, 1882	38,841 74

NATCHEZ AND VIDALIA.

	By Captain Miller.	By Major Stickney.	Total.
able June 30, 1882, from former appropriations..	$8,252 04	....	$8,252 04
nded...	722 95	$2,197 67	2,920 62
Balance available November 1, 1883	*7,529 09	—2,197 67	5,331 42

* Transferred to Major Stickney, September 9, 1882.

OBSERVATIONS AT CARROLLTON, LA.

he allotment of $3,000 from the appropriation for improving Mississippi River has n drawn and expended by Major Stickney. The observations are now being carl on with an allotment from the appropriation for Mississippi River Commission.

SURVEY OF UNLEVEED FRONTS IN THIRD DISTRICT.

rwn by Captain Marshall..	$1,000 00
pended by Captain Marshall..	496 96
Balance available November 1, 1883............................	503 04

ll the allotment, viz: $1,000, has been drawn.

SURVEY OF UNLEVEED FRONTS IN FOURTH DISTRICT.

otment	$1,000 00

lone of which has been drawn or expended.

SURVEY OF CUBITT'S GAP.

rwn by Major Stickney..	$300 00
pended by Major Stickney	137 14
Balance available November 1, 1883............................	162 86

ll the allotment, viz: $300, has been drawn.

DELTA POINT, LOUISIANA.

ance from another appropriation	$25,770 13
otment from appropriation for improving Mississippi River	50,000 00
Available June 30, 1882	75,770 13
pended by Captain Marshall..	75,762 49
Balance on hand	7 64

his work is finished.

CHOCTAW BEND SURVEY.

awn by Captain Marshall	$2,700 00
pended by Captain Marshall	2,679 86
Balance in hand..	20 14
otment from current appropriation.................................	4,000 00
awn	2,700 00
Balance in Treasury	1,300 00
Balance in hand	20 14
ailable for transfer to other works	1,320 14

This survey has been completed.

[illegible]

[illegible]	$100
[illegible]	102
[illegible]	− 2
[illegible]	110,
[illegible]	100,
[illegible]	10,
[illegible]	− 2,
Dra[illegible] Exp[illegible]	7,
[illegible]	$426,
[illegible]	251,
Avail[illegible]	174,
Balan[illegible]	1,315,
Balan[illegible]	1,285,
Availab[illegible]	30,
[illegible]	230,
[illegible]	260,

SUMMARY.

allotments	$3,978,800 00
lotted and in Treasury	144,200 00
lotted and in hands of Captain Sears, from sale of fuel to himself.	126 00
Total appropriation	4,123,126 00
from last appropriation	36,230 86
from other appropriations	272,628 38
Total	4,431,985 24
nted for as follows:	
S. Treasury, not drawn	607,025 90
nded	3,433,716 04
ds of disbursing officers	391,243 30
Total	4,431,985 24
ailable November 1, 1883, for works carried on under the Mis- River Commission	998,269 20

eater portion of this available balance will be exhausted by January 1, 1884. rge amount of public property to be taken care of, and the uncertainty con- the time when another appropriation will be made, makes it desirable to re- ficient funds to amply provide for such care of property. I would, therefore, d to the Commission that the work on the several reaches be brought to a an early date, and the forces be reduced to the lowest point compatible with per protection of the works, the care of public property, and the settlement nts.

which is respectfully submitted.

CLINTON B. SEARS,
Captain, Engineers, U. S. A.,
Executive Officer, Construction Dep't, M. R. C.

Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

			[illegible]	Mouth of Red River	Lake Providence Reach. Bayou Plaq, and mouth of Red River.
	1	807 00	807 00	Memphis, Plum Point, and Lake Providence.	General service, Stone Depot.
	1	1,535 00	1,535 00	Plum Point	Plum Point Reach.
...rs	2	202 00	404 00	......do	Do.
... outfits	2		765 90	Plum Point, Memphis, and Lake Providence.	General service steamers.
	3		2,559 85	Plum Point	Plum Point Reach.
	1	938 50	938 50	Lake Providence	Lake Providence Reach.
	7	39 93	279 50	Plum Point, Memphis, and Lake Providence.	General service.
			172 00	Plum Point	Plum Point Reach.
			325 00	Plum Point, Memphis, and Lake Providence.	General service, Stone Depot.
			3,489 40	......do	General service.
			14,849 21	Plum Point	Plum Point.
			664 26	Memphis	Memphis Reach.
Do			4,111 60	Lake Providence	Lake Providence Reach.
Total			588,201 97		

List of plant purchased by Capt. C. B. Sears, Corps of Engineers, U. S. A., from December 1, 1882 to November 1, 1883.

Description.	No.	Average first cost of each.	Total cost.	Allotment or appropriation from which paid.	Where used.
Steam tow-boat [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam tug [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam l[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Date.	Voucher.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1882.													
Dec. 7	48	Pens			$1 09								
1	203	Rent						$60 00					
5	229	Gas							$9 78				
4	238	Ice		$112 50			$17 40						
	240	Furniture	$611 00										
30	241	Pay-roll				$200 00		5 00					
	251	Stationery		41 60	25 30								
	252	Outfit											
12	255	Mileage									$100 86		
15	263	Traveling expenses				35 80							
18	269	......do				11 50							
25	310	Mileage									170 56		
27	315	Fuel										$23 60	
20	316	Street-car tickets				10 00							
29	320	Telegrams								$124 30			
1883.													
Feb. 5	15	......do								34 01			
Jan. 2	23	Rent						60 00					
Feb. 5	48	Outfit (lamp and shade)		3 50									
Jan. 17	58	Paper and envelopes			29 45								
16	59	Oil							10 14				
15	62	Street-car tickets				10 00							
Feb. 1	69	Telegrams								1 36			
Jan. 6	70	Gas							6 25				
31	75	Water					7 50						
12	80	Mileage									51 68		
27	158	Fuel										23 60	

	19	79	Mileage	612 00										
	27	82	Sprinkling street				10 00						4 73	
	31	94	Pay-roll (July)									34 00		
	2	95	Telegrams											
	2	96	Street-car tickets						60 00					
	30	111	Coal					7 50						
	25	121	Mileage											
Aug.	1	127	Rent			2 96					20 17			
	1	128	Water					11 45						
	4	134	Stationery											
	8	146	Telegrams		2 50							51 20		
	9	149	Ice											
	15	188	Frames			49 00								
	18	189	Mileage					6 00						
	17	202	Stationery										4 73	
	29	230	Sprinkling street									56 88		
	29	236	Coal											
	27	244	Mileage									51 20		
	29	245	do											
	31	253	Pay-roll (August)	753 50										
	4	258	Traveling expenses				7 50							
	4	261	Street-car tickets				10 00							
	30	268	Soap			1 15								
Sept.	3	280	Stationery		3 75									
	1	298	Rent						60 00					
	1	311	Mileage									24 00		
	8	328	Telegrams								30 60			
	18	349	Stationery			6 00								
	17	372	Mileage									51 20		
	18	375	Rubber stamps		3 50									
	21	394	Stationery			5 80								
	22	400	Sprinkling					6 00						
	25	409	Stationery			6 30								
	8	414	Repairs						4 50					
	8	415	Telegrams								5 38			
	8	416	Traveling expenses				10 80							
	8	417	Telegrams								68			
	29	419	Pay-roll (September)	746 00										
	26	420	Coal										22 60	
	28	422	Street-car tickets				10 00							
	30	431	Mileage									24 00		
Oct.	1	3	Rent						60 00					
	7	10	Mileage									73 28		
	8	20	Gas							2 38				
	22	42	Supplies			9 85								
	20	62	Stationery			10 38								
	20	66	Gas-fixtures						85					
	20	70	Tape		4 50									
	24	79	Telegrams								2 25			
	24	80	Mileage									38 40		

Itemized statement of expenditures for improving the Mississippi River from December 1, 1882, to October 31, 1883, both inclusive—Continued.

OFFICE—Continued.

Date.	Voucher number.	For what expended.	Pay-roll.	Furniture and outfit.	Stationery.	Transportation and traveling expenses.	Ice and water.	Rent and repairs.	Gas and fuel.	Telegrams.	Mileage.	Fuel for Capt. C. B. Sears.	Total.
1883.													
Oct. 29	86	Pay-roll	$748 50										
2	87	Traveling expenses				$10 50							
2	89	......do				11 80							
2	90	......do				12 95							
24	92	Sprinkling street					$6 00						
22	102	Telegrams								$30 54			
29	114	Fuel										$23 60	
		Total	8,469 83	$390 95	$377 47	1,400 85	79 91	$669 85	$170 97	344 75	$1,289 12	160 48	$13,354 12

			....do											
			Mileage									13 28		
			Sprinkling street					6 00						
			Pay-roll (July)	812 00										
			Telegrams								25			
			Street-car tickets				10 00							
			Coal										4 72	
			Mileage									24 00		
			Rent						60 00					
			Water					7 50						
			Stationery			2 96								
	[illegible]		Telegrams								20 17			
	9		Ice					11 45						
	15		Frames		2 50									
	13		Mileage									51 20		
	17		Stationery			49 00								
	29		Sprinkling street					6 00						
	29	[illegible]	Coal										4 72	
	27	244	Mileage									56 88		
	29	245	......do									51 20		
	31	253	Pay-roll (August)	753 50										
	4	258	Traveling expenses				7 50							
	4	261	Street-car tickets				10 00							
	30	268	Soap			1 15								
Sept.	3	280	Stationery		3 75									
	1	298	Rent						60 00					
	1	311	Mileage									24 00		
	8	328	Telegrams								30 60			
	13	349	Stationery			6 00								
	17	372	Mileage									51 20		
	18	375	Rubber stamps		3 50									
	21	394	Stationery			5 80								
	22	400	Sprinkling					6 00						
	25	409	Stationery			6 30								
	8	414	Repairs						4 50					
	8	415	Telegrams								5 38			
	8	416	Traveling expenses				10 80							
	8	417	Telegrams								68			
	29	419	Pay-roll (September)	746 00										
	26	420	Coal										23 60	
	28	422	Street-car tickets				10 00							
	30	431	Mileage									24 00		
Oct.	1	3	Rent						60 00					
	7	10	Mileage									73 28		
	8	20	Gas							2 38				
	22	42	Supplies			9 85								
	20	62	Stationery			10 38								
	20	66	Gas-fixtures						35					
	20	70	Tape		4 50									
	24	79	Telegrams								2 25			
	24	80	Mileage									38 40		

Itemized statement of expenditures for improving the Mississippi River from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

OFFICE—Continued.

Date.	Voucher number.	For what expended.	Pay-roll.	Furniture and outfit.	Stationery.	Transportation and traveling expenses.	Ice and water.	Rent and repairs.	Gas and fuel.	Telegrams.	Mileage.	Fuel for Capt. C. B. Sears.	Total.
[illegible]3.													
29	86	Pay-roll	$748 50										
[illegible]	87	Traveling expenses				$10 50							
	89	do				11 80							
	90	do				12 95							
		Sprinkling street					$6 00						
		Telegrams								$30 54			
		Fuel										$23 60	
		Total	8,469 83	$390 95	$377 47	1,400 85	79 91	$669 85	$170 97	344 75	$1,289 12	160 48	$13,354 12

Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
$40 00								
13 32								
10 78								
							$150 00	
							155 00	
							439 25	
56 60			$15 75					
2 31								
77 12								
							155 00	
19 44								
							405 00	
							50 00	
							341 50	
12 90								
							140 00	
4 53								
							155 00	
							361 00	
				$14 58				
		$22 50						
[illegible] 29			1 00					
							355 00	
				3 00				
			150 00					
			14 37					
		314 43						
							301 00	
			6 35					
[illegible]								
							235 00	
[illegible]								

Itemized statement of expenditures for improving the Mississippi River from December 1, 1882, to October 31, 1883, both inclusive—Continued.

OFFICE—Continued.

Date.	Voucher number.	For what expended.	Pay-roll.	Furniture and outfit.	Stationery.	Transportation and traveling expenses.	Ice and water.	Rent and repairs.	Gas and fuel.	Telegrams.	Mileage.	Fuel for Capt. C. B. Sears.	Total.
1883.													
Oct. 29	86	Pay-roll	$748 50										
2	87	Traveling expenses				$10 50							
2	89	do				11 80							
2	90	do				12 95							
24	92	Sprinkling street					$6 00						
22	102	Telegrams								$30 54			
29	114	Fuel										$23 60	
		Total	8,469 83	$390 95	$377 47	1,400 85	79 91	$669 85	$170 97	344 75	$1,289 12	160 48	$13,354 12

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

COAL FLEET—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883. July 3	55	Office expenses		$0 25				$0 75					
3	56	Subsistence									$0 87		
[illegible]	122	Pay-roll, July										$247 00	
[illegible]	[illegible]	Subsistence									1 87		
		[illegible]							$0 75				
		[illegible] public property										10 00	
		[illegible]						50					
		[illegible]						1 00					
		[illegible]										238 00	
		[illegible]						87	12 00				
		[illegible]								$10 00			
		[illegible]											
		[illegible]										221 50	
		[illegible]								104 75			
		[illegible]									4 85		
										114 75	7 59	3,959 25	$5,009 26

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
Feb. 15		Supplies			[illegible]								
17		Stationery			[illegible]								
18		Outfit					[illegible]						
19		Labor and material			[illegible]			[illegible]					
20	230	Guide and insulater			1 40								
22	239	Supplies			58 68			1 00					
27	252	Labor and material			30 40					[illegible]			
28	254	Subsistence									[illegible]		
3	255	......do									[illegible]		
3	256	Labor								12 50			
3	257	Subsistence									14 80		
28	258	Pay-roll (February)						1,278 48			145 00	[illegible]	
Mar. 1	264	Supplies			[illegible]						[illegible]		

	[illegible]	34[illegible]												
	24	355	[illegible]											
Aug.	2	2	Subsistence											
	2	4	Labor and repairs											
	6	19	Grate-bars											
	7	22	Subsistence											
	7	29	Steam-fittings											
	9	34	Labor, materials, and repairs											
	11	48	......do											
	10	54	Services											
	12	55	Meat											
	12	59	Supplies			19 66								
	13	66	Subsistence											
	16	85	......do											
	23	125	Supplies					5 00						
	23	130	......do						5 65					
	26	133	Outfit					43 94	1 00					
	30	147	Services						17 50					
Mar.	31	159	Pay-roll (March)						175 53					
Apr.	2	160	Meat											
	2	161	Labor								32 60			
	2	162	Meat									7 75		
	2	163	Labor								30 00			
	30	164	Pay-roll (April)						1,256 51			175 00	45 00	
May	5	172	Labor								26 62			
	5	176	Transportation						10 00					
	11	182	Supplies			123 88								
	11	183	......do			14 75					4 50	28 51		
	11	185	......do			17 80								
	11	186	......do			8 90						24 10		
	11	189	......do			101 10								
	11	193	Press-book			8 15								
	11	205	Supplies									48 84		
	11	206	Outfit					15 25		12 85				
	11	207	Meat and ice									61 16		
	11	208	Tarpaulins					66 00						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

STEAMER MISSISSIPPI—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
[illegible]	[illegible]	[illegible]								$3 60			
[illegible]	[illegible]	[illegible]						$3 00					
[illegible]	[illegible]	[illegible]									$2 00		
[illegible]	[illegible]	[illegible]						1 00					
[illegible]	[illegible]	[illegible]						1,041 84			100 00	$40 50	
[illegible]	[illegible]	[illegible]						1 50					
[illegible]	[illegible]	[illegible]									189 00		
[illegible]	[illegible]	[illegible]									41 36		
[illegible]	[illegible]	[illegible]						1,334 85			158 00	45 00	
[illegible]	[illegible]	[illegible]									86 20		
[illegible]	[illegible]	[illegible]									14 30		
[illegible]	[illegible]	[illegible]								3 00			
[illegible]	[illegible]	[illegible]								12 50			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

			[illegible]											
			[illegible]											
			......do											
			Pay-roll (July)											
			Kevel											
			Outfit											
			Labor and material											
			Paper											
			Rings											
			Supplies and subsistence											
			......do											
			Transportation											
			......do											
			Subsistence											
			Frames			3 75								
			Subsistence											
Sept.	3		Stores and supplies			37 68								
	3	[illegible]	......do			6 25								
	8	319	Lamps			16 70								
	8	322	Stores and supplies			18 01								
	4	323	Pay-roll											
	10	332	Subsistence											
	10	333	Lumber							[illegible]				
	10	334	Supplies							[illegible]				
	10	335	Subsistence											
	10	336	Stores and supplies			3 25						[illegible]		
	13	351	Oil-can			6 50								
	17	366	Stationery		5 00									
	17	374	Subsistence									42 00		
	4	388	......do									26 43		
	4	389	Labor								26 15			
	4	390	Labor and material							20 75				
	22	399	Fire-hooks			4 86								
	30	444	Machinery repairs							55 88				
	30	446	Subsistence									63 70		
	30	471	Pay-roll (September)						1,615 37					
Oct.	1	1	Repairs							27 00				
	2	4	Paper		3 96									
	9	9	Subsistence									22 30		
	10	17	......do									25 60		
	26	26	Services						8 75					
	22	28	Subsistence						5 60			175 22		
	22	38	Supplies			434 78			7 85			16 00		
	20	44	Labor								4 50			
	22	59	Supplies						1 40			58 80		
	20	63	Grate-bars							3 15				

Itemized statement [illegible]

Date.	Voucher.	[illegible]	[illegible]	[illegible]	[illegible]	Fuel.	[illegible]	[illegible]	Repairs.	[illegible]	Subsistence.	[illegible]	Total.
1882. Dec. 23	88	Capstan wheels							$30 80				
24	91	Subsistence									$35 50		
25	93	Labor and material							37 50				
26	100	Castings							7 85				
26	101	Lumber							2 86				
29	109	Wicks and shades			$0 20		$4 80						
29	113	Repairs							248 50				
29	115	Subsistence									34 20		
		Totals		$46 51	2,133 99	$33 21	224 17	12,845 45	1,517 42	$693 59	5,062 16	$370 00	$22,926 50

STEAMER EMMA ETHERIDGE.

Date.	Voucher.	[illegible]	[illegible]	[illegible]	[illegible]	Fuel.	[illegible]	[illegible]	Repairs.	[illegible]	Subsistence.	[illegible]	Total.
1882.	202	Coal				34 00							
	213	Stores and supplies			144 28					3 00	152 73		
Dec. 1	220	Meat									23 00		
2	235	Pay-roll (November)						1,032 62			115 00		
	Part, 252	Outfit						4 50					
22	305	Repairs (machinery)						15 65					
24	314	Labor								27 75			
28	317	Pay-roll (December)						1,054 17			113 63		
1883. Jan. 3	6	Labor and repairs						240 51					
3	7	Outfit			32 85			1 00					
3	10	do			[illegible]			[illegible]					

Jan.	17	64	Stencils											
	25	66	Repairs (machinery)						19 60					
	25	66	Subsistence											
	25	78	do									50 70		
Feb.	5	83	Labor and material			236 69								
Jan.	25	94	Supplies			3 60		18 65	2 35					
	30	129	do											
	30	132	Grate-bars, &c											
	30	Part, 137	Paper			3 08			2 25					
	30	141	Transportation									11 40		
	18	146	Meat								9 00			
	18	147	Labor											
	18	148	Union			50								
	18	149	Labor								23 90			
	18	150	do								1 50			
	18	151	do								24 56			
	18	152	Repairs						26 55					
	31	153	Pay-roll (January)						994 00			82 83	$26 67	
Feb.	5	165	Labor and material			5 00					16 50			
	5	181	do			15 01					60 00			
	12	192	Meat									9 00		
	15	205	Shovels					9 85						
	15	214	Supplies			19 89						121 34		
	16	222	Grate-bars			30 65			3 05					
	17	223	Stationery			4 65								
	20	231	Picks and handles					5 20						
	20	232	Meat									26 82		
	20	233	Ice									6 54		
	21	234	Nails			3 00								
	20	235	Lumber			8 53								
	22	240	Outfit					34 20	95					
	28	242	Pay-roll (February)						1,067 17			149 50	40 00	
	27	250	Material and labor			5 76					21 00			
	27	251	Stationery		$12 70				40					
Jan.	30	265	Labor								22 00			
	30	266	do								15 10			
	30	267	do								12 45			
	30	268	Supplies			5 00								
	30	269	Boat-spikes			1 75								
	30	270	Supplies			1 30								
	30	272	Meat									15 60		
Mar.	3	Part, 282	Blanks		14 50									
	7	301	Meat									11 80		
Mar.	9	314	Labor						7 00					
	9	315	Oars					2 50						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

STEAMER EMMA ETHERIDGE—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Other expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Mar. 9	316	Meat									$7 00		
10	319	Transportation						$7 00					
12	322	Lumber			$11 27								
13	Part, 325	Frames		$2 70									
24	348	Outfit			61 78								
24	Part, 355	Stationery		12 75									
26	359	Labor						59 45					
24	360	Labor and material			263 00			314 00					
31	362	Pay roll (March)						246 52			93 94	$9 93	
31	363	do						507 50					
31	364	Subsistence									9 40		
28	368	Lamps					$7 25	60					
31	375	Labor and material			167 94			218 35					
Apr. 2	1	Outfit					450 00						
6	12	do					12 75						
6	14	Repairs							$51 99				
6	15	Carpet					9 60						
6	18	Subsistence									90 05		
6	20	Grate-bars							27 50				
7	24	Subsistence									56 85		
7	26	Tarpaulins					26 50						
7	27	Labor							65 63				
7	28	Subsistence									84 15		
7	30	Stationery		6 20									
9	38	Labor and material			11 92					$5 25			
10	40	Subsistence									6 50		
10	42	Asbestos covering							53 10				
11	49	Electric outfit					765 90						
10	53	Labor and material							26 05				
12	60	Labor and supplies			290 04					5 50			
13	63	Supplies			105 71								
13	64	Labor and material								109 04			

	[illegible]	[illegible]	......do.						1,119 53			165 60	40 00	
	30	149	Pay-roll (April)									8 00		
	2	150	Eggs								9 50			
	2	151	Labor											
	2	152	Sundries			2 75								
	2	153	Meat									9 00		
	2	154	Labor								19 75			
May	11	187	Oil			15 00								
	1	191	......do.			65 84								
	11	201	Pump						197 50					
	11	202	Ice									9 85		
	11	203	Labor and material							105 05				
	11	204	......do.							68 25				
	2	214	Traveling expenses						6 00					
	14	231	Supplies			11 63			20					
	18	242	Subsistence									8 35		
	18	243	Transportation						6 50					
	18	244	Subsistence									30 60		
	18	245	Meat									27 00		
	22	250	Subsistence									17 60		
	22	251	Labor							10 00				
	23	256	Eggs									3 60		
	23	257	Meat									11 00		
	25	261	Subsistence						4 40			165 49		
	26	269	Supplies			45 29			70					
June	1	281	Clock					5 50						
May	31	282	Pay-roll (May)						1,143 15			146 17	41 38	
Apr.	30	283	Labor								21 50			
	30	284	Frame					85						
	30	285	Fish									1 93		
	30	286	Services						10 00					
	30	287	Subsistence									10 25		
	30	288	....do.									4 68		
	30	289	Meat									18 20		
	30	290	Subsistence									4 60		
	30	291	Labor								18 12			
	30	292	Supplies			1 35								
	30	293	Subsistence									4 10		
	30	294	.... do.									8 95		
	30	295	Labor								5 00			
June	2	301	Subsistence									8 67		
	2	304	Plank							11 90				
	2	305	Subsistence									25 50		
	4	307	Skiffs					17 00						
	5	Part, 326	Envelopes		1 50									

Itemized statement of expenditures for improving ... River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

STEAMER EMMA ...—Continued.

Date.	Voucher number.	For what expended.	[illegible]	[illegible]	Material and mineral supplies.	Fuel.	Care of plant.	Transportation and other expenses.	Repairs.	Labor ...	Subsistence.	Care of ...	Total.
1883.													
5	327	Liner-boxes							[illegible]				
May 29	360	Labor								[illegible]			
29	361	Lumber, repairs							[illegible]				
29	362	Labor								[illegible]			
29	363	Subsistence									[illegible]		
June 18	368	Meat									[illegible]		
18	371	Ice									[illegible]		
25	403	Repairs							[illegible]				
30	412	Pay-roll (June)						[illegible]			[illegible]	[illegible]	
May 29	413	Labor								[illegible]			
29	414	do								[illegible]			
29	415	Supplies									[illegible]		
July 3	1	Repairs							[illegible]				
2	2	Subsistence									[illegible]		
2	3	do									[illegible]		
3	9	do									[illegible]		
5	16	Supplies			[illegible]								
6	24	Repairs							[illegible]				
6	20	Supplies			[illegible]								
14	49	Repairs							[illegible]				
13	52	Subsistence									[illegible]		
14	54	Repairs							[illegible]				
16	58	Supplies			[illegible]								
16	62	Subsistence									[illegible]		
17	65	Supplies			[illegible]								
17	66	Repairs							[illegible]				
19	68	Subsistence									[illegible]		
19	69	do									[illegible]		
19	71	Repairs							[illegible]				
24	73	Supplies			1 75								

Aug. [illegible]	[illegible]	Supplies									6 00		
7	144	Subsistence			17 42								
8	145	Supplies							44 24				
8	148	Repairs			18 00								
10	164	Supplies									68 50		
15	181	Subsistence									104 81		
15	185	....do							12 92				
15	186	Repairs							20 20				
16	191	Labor and material			57 97								
16	197	Chains			16 58								
16	198	Castings							37 40				
17	199	Labor and material							1 00				
17	200	Labor		$4 50									
17	201	Stationery							9 80				
17	206	Patterns			1 85								
17	208	Supplies							6 88				
27	220	Lumber			42 00			98					
29	227	Ratchets						2 50			32 36		
29	228	Supplies			11 50								
29	229	Supplies and outfit							18 80				
29	231	Brasses and cups						1,119 52					
31	246	Pay-roll (August)								2 50			
4	247	Cleaning boilers								20 00			
4	248	Labor									12 56		
4	249	Meat									6 20		
4	250	Vegetables									5 00		
4	251	Ice						19 60					
4	252	Transportation								10 50			
4	254	Services			1 75				3 40		9 80		
Sept. 3	289	Stores and supplies			5 20								
1	290	......do								1 00			
Aug. 30	309	Making affidavits						9 50					
Sept. 1	310	Transportation			2 50				2 00				
6	312	Stores and supplies						1 50					
8	321	Traveling expenses						1 50					
10	337	......do									27 75		
11	338	Subsistence							24 88				
14	361	Repairs to machinery						1 00					
14	365	Traveling expenses		5 00									
17	366	Stationery			2 20			2 50			7 65		
20	393	Stores and supplies							25 66				
24	403	Lumber									9 50		
27	421	Meat								2 75			
30	445	Labor											

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

STEAMER EMMA ETHERIDGE—Continued.

Date.		Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
[illegible]	[illegible]	[illegible]	[illegible]											
	[illegible]	[illegible]	[illegible]											
Aug.	30	[illegible]	Pay-roll											
	30	[illegible]	Supplies											
	30	[illegible]	Transportation											
	30	464	......do											
	30	465	Making affidavits		[illegible]									
	30	466	Eggs											
	30	467	Vegetables											
Oct.	2	4	Paper		[illegible]									
	22	30	Stores and supplies			[illegible]			[illegible]			[illegible]		
	22	35	Supplies			[illegible]			[illegible]			[illegible]		
	20	43	Transportation						[illegible]					
	20	67	Bell					[illegible]						
	22	74	Subsistence									[illegible]		
	22	75	......do									[illegible]		
	12	77	......do									[illegible]		
	12	78	Pay-roll										[illegible]	
	25	98	Subsistence									[illegible]		
	29	119	Pay-roll						213 51					
	29	122	......do						514 00					
			Totals		65 31	2,310 28	$34 00	1,420 50	12,954 22	$1,003 94	$564 90	[illegible]	[illegible]	[illegible]

CHARTERED STEAMER JOHN DIPPOLD.

	27	214	Subsistence											
	27	215	......do									[illegible]		
	27	219	Coal				460 75							
	29	225	Subsistence									40 58		
	29	233	Lumber							8 70				
	29	234	Labor								7 50			
	29	235	Labor and material							5 65				
	29	242	Supplies			613 12								
	30	263	Subsistence									78 07		
	30	264	......do									41 50		
	30	265	......do									80 42		
	30	270	......do									60 66		
Sept.	3	281	......do									1 66		
	3	286	Charter						1,250 60					
	3	290	Coal				219 34							
	3	291	Subsistence									23 50		
	3	302	Pay-roll						1,409 91					
Aug.	6	303	Stores and supplies			23 65						17 27		
	6	304	Subsistence									9 00		
	6	305	Transportation						1 90					
	6	306	......do						50					
	6	307	Subsistence									5 00		
Sept.	10	335	......do									12 74		
	12	341	......do									33 04		
	12	342	......do									14 25		
	13	357	Coal				1,283 73							
	14	362	Subsistence									18 60		
	14	363	......do									72 44		
	17	364	Coal				631 01							
	25	410	Stationery		5 45									
	30	427	Supplies			13 80								
	30	428	Supplies and stores			4 95						110 08		
	30	430	Coal				44 81							
	30	440	Charter						1,500 00					
	30	442	Stores and supplies			8 45						76 85		
	29	472	Pay-roll						1,704 45					
	3	473	Labor								16 00			
	3	474	Subsistence									80		
Oct.	2	5	Transportation						7 00					
	9	8	......do						5 00					
	10	12	Subsistence (ice)									20 00		
	10	13	......do									15 55		
	10	15	Subsistence (apples)									2 60		
	10	16	......do									39 10		
	22	29	......do						10 20			270 17		

[illegible]—A statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

CHARTERED STEAMER JOHN DIPPOLD—Continued.

Date.		No. of voucher.	On what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
[illegible]	[illegible]	[illegible]	[illegible]								$16 00			
	[illegible]	[illegible]	[illegible]				$291 51							
	[illegible]	[illegible]	[illegible]			$206 52			$3 36					
	[illegible]	[illegible]	[illegible]						405 33					
[illegible]	[illegible]	[illegible]	[illegible]		$0 95									
	[illegible]	[illegible]	[illegible]								1 25			
	[illegible]	[illegible]	[illegible]			3 00								
[illegible]	[illegible]	[illegible]	Transportation						7 00					
			Totals		[illegible] 40	1,199 20	3,665 60		6,372 65	$14 35	40 75	$1,208 60		$12,507 55

CHARTERED STEAMER REINDEER.

Date.		No. of voucher.	On what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
Sept.	[illegible]	[illegible]	Subsistence									26 15		
	[illegible]	[illegible]	do									11 95		
	[illegible]	[illegible]	Supplies			1 02								
	[illegible]	[illegible]	Stores and supplies			2 00	5 00					6 85		
Aug.	30	[illegible]	Pay roll						311 18					
Sept.	6	[illegible]	Subsistence									20 85		
	6	[illegible]	Coal				6 50							
	12	[illegible]	Pay roll						148 80					
	12	347	Coal and subsistence				42 00					13 75		
	13	358	Coal				56 00							
	14	397	Services						8 00					
Oct.	22	50	Coal				24 00							
			Totals			3 02	133 50		467 98			79 55		684 05

Oct. 2	4	Paper											
22	36	Supplies			42 29			90					
22	52	Stores and supplies			75						56 35		
22	60	Medicines									15 02		
20	64	Frames						4 50					
22	72	Stores and supplies			33 15			6 50			231 21		
22	73	Supplies			3 74								
22	76	Coal				427 60							
15	120	Labor						19 42					
29	123	Pay-roll						273 92					
		Totals		8 96	360 09	427 60		307 59			302 58		1,406 82

CHARTERED STEAMER JACK FROST.

Sept. 10	335	Subsistence									6 37		
18	376	......do									30 15		
18	380	Subsistence and supplies			90						353 31		
18	381	Supplies			38 20								
21	395	Stationery		7 25									
25	406	Supplies			6 00								
25	411	Stationery		3 50									
30	432	Subsistence									40 60		
30	436	Coal				160 00							
30	438	Subsistence and supplies			1,613 48						22 66		
30	439	Charter						800 00					
30	453	Pay-roll (September)						891 00					
Aug. 30	455	Supplies			15 00								
30	456	Traveling expenses						2 50					
30	457	Subsistence									12 00		
30	458	......do									10 84		
30	459	Fender			2 10								
30	460	Traveling expenses						2 50					
30	461	Subsistence									9 65		
30	468	......do									4 50		
30	469	Labor								6 00			
30	470	Hauling						75					
Oct. 2	4	Paper		1 32									
10	14	Ice									15 03		
10	18	Subsistence									25 50		
10	19	Meat									22 50		
22	31	Coal				559 12							
22	32	......do				327 47							

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

CHARTERED STEAMER JACK FROST—Continued.

Date.	Voucher.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Sept. 22	41	Stores and supplies			$63 34			$2 10			$0 90		
22	57	Coal				$84 60							
20	71	Hose					$19 25						
29	116	Charter						800 00					
29	117	Pay-roll						841 57					
Sept. 30	118	Labor								$4 00			
		Totals		$12 07	1,739 02	1,131 19	19 25	3,340 42		10 00	554 01		$6,805 96

PLUM POINT REACH.

Capt. J. G. D. KNIGHT.

Date.	Voucher.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
Dec. 1	215	Fire brick and clay			12 50			6 05					
1	216	Subsistence						22 75			569 50		
	217	do									221 25		
Dec. 2	218	do						1 00			28 90		
4	221	Stone			368 83								
1	228	Outfit, quarter-boats					18 50	1 00					
2	232	Subsistence						17 85			466 29		
4	234	do						10 50			270 00		
5	236	Supplies			27 50			1 00					
6	245	Rope			134 87								
12	254	Towage						48 00					
4	266	Material			115 79			4 25					

11	302	Outfit					[illegible]	[illegible]					
20	304	Supplies			2,579 47			18 55					
19	306	......do			21 24			35					
20	308	Subsistence						33 80			1,694 65		
25	311	Outfit					154 88	1 65					
9	312	......do					20 80	65					
26	318	Copying official papers		$12 40									
1883. Jan. 6	9	Gum cutters			4 00								
6	13	Transportation						5 53					
5	24	Outfit, quarter-boats					720 00	9 70					
15	26	Services										96 50	
6	27	Supplies			72 82			3 70					
6	28	Straw			56 49			20 00					
9	31	Washing-machines			288 00			3 10					
4	34	Advertisement for material			15 41								
9	35	Advertisement for stone			22 80								
10	36	Labor						7 00					
4	37	Advertisement for material			20 72								
16	40	Salt					76 25						
15	42	Mileage	11 84										
25	43	Supplies			295 79			6 40					
29	47	Apples						5 00			75 00		
25	49	Skiffs					102 00						
17	51	Lamps			74 75								
17	53	Blocks			115 20			3 15					
17	55	Labor and material					17 82						
16	56	Door-liners						10 52					
17	60	Supplies (sub)						34 60			757 78		
5	63	Outfit, quarter-boats					2,313 74	28 70					
25	67	Stone			1,147 75								
25	72	Oil			190 30								
25	90	Outfit, graders					378 00	3 10					
25	92	Tarpaulins										162 50	
25	93	Duck						261 95					
25	95	Supplies			210 40								
25	97	Stores and supplies			87 15						24 64		
26	103	Subsistence									135 26		
16	106	Supplies			167 93						49 22		
29	107	Outfit, quarter-boats					9 68						
25	108	Transportation						3 00					
27	110	Supplies			15 00						66 00		
27	112	......do			21 20						107 40		
27	114	Outfit, quarters					230 33						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Jan. 31	120	Services	$30 00										
29	122	Supplies			$137 04						$13 62		
29	123	Anchors					$195 75						
29	125	Vinegar									24 93		
29	126	Outfit, quarters					190 21						
30	128	Apples									73 13		
30	136	Supplies			38 20								
30	142	Transportation						$53 53					
31	144	Pencils		$31 80									
30	154	Services	108 33										
31	159	Labor (loading stores)						8 00					
Feb. 3	163	Outfit, quarters					46 40						
3	174	Services										$32 00	
3	175	Stone			683 10								
Jan. 25	183	Traveling expenses	3 00										
Feb. 7	188	Wire			3,084 06			75 53					
6	195	......do			7,542 11			164 69					
12	198	Mess outfit					148 45						
2	203	Transportation						65					
15	204	Supplies			3,461 70								
15	206	Outfit					335 56						
14	208	Services										14 00	
16	211	Supplies			66 60						890 65		
16	212	......do									104 98		
17	213	Hardware			25 70								
16	215	Bolts and rope			35 63								
16	217	Can fruit									85 60		
16	218	Sugar									197 60		
17	224	Subsistence									445 00		

	[illegible]	[illegible]	Rope			[illegible]			[illegible]					
	5	287	Tape and rule					4 15						
	5	289	Hams						1 00			34 44		
Feb.	24	291	Advertising for materials			11 90								
Mar.	6	294	Knobs			4 00			1 00					
	7	298	Grate-bars			36 85			2 00					
	6	299	Supplies			416 28			10 75					
	7	300	Rope			264 90			6 50					
	8	302	Towing						5 00					
	8	304	Brushes			62 50			1 00					
Feb.	24	305	Advertising for material			11 42								
	27	313	Stone			407 74								
Mar.	5	318	......do			405 40								
	12	324	Labor						30 00					
	14	328	Supplies						2 75			60 30		
	24	345	Labor						37 13					
	24	346	Lumber			226 08								
	24	347	Hose			78 75			1 00					
	24	353	Supplies			268 62			2 80					
	24	356	Books			5 50								
	26	358	Potatoes						17 50			125 00		
	28	367	Skiffs and oars					260 50						
	31	377	Services	37 50										
	31	383	......do	62 50										
	30	384	Wire			4,013 30								
Apr.	2	6	Services	87 00										
	6	16	Labor						13 06					
	7	25	Towage						10 09					
	9	36	Supplies			59 78								
	9	37	Reducers			5 00								
	10	39	Straw			37 30								
	10	41	Outfit					4 92						
	10	43	......do					426 50	6 75					
	11	47	Supplies					20 70						
	11	50	Ranges					285 00						
	12	56	Stationery		13 75									
	12	57	Outfit					96 70	2 00					
	13	61	......do					212 65	5 82					
	13	62	Supplies			287 34								
	13	65	......do			75 58						669 96		
	14	68	Outfit					553 08						
	11	69	Traveling expenses	26 70										
	14	70	Hoisting-engine					1,585 00						
	6	73	Labor						67 50					
	6	74	Stone			212 85								
	16	76	Hardware			256 62								

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 13, 1883, both inclusive—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Apr. 16	78	Straw			$24 20								
16	81	Supplies					$63 75	$1 00					
16	82	do			151 20			2 81					
16	83	Outfit					637 50	8 75					
16	84	Subsistence						39 30			$1,007 96		
17	86	do						24 00			580 00		
17	87	Hardware			17 01			1 00					
17	88	Subsistence						1 00			57 80		
17	89	Rubber boots			54 27			1 00					
17	93	Outfit			46 08			50					
17	94	Labor and material										$35 10	
17	95	Supplies			3 00								
17	96	Paint			250 50								
17	97	Liner-boxes							$8 40				
18	99	Supplies			105 24			22 35			360 00		
18	100	do						8 20			240 40		
18	101	Outfit					480 40	9 02					
18	102	Subsistence						16 35			313 65		
18	104	Outfit					10 28						
19	107	do					72 28	1 00					
19	109	do					65 32						
19	110	do					172 91						
19	111	do					261 34						
19	113	Stone			125 77								
19	114	Wire rope			803 68			22 50					
20	115	Outfit					527 80						
20	117	Chairs					5 25	1 00					

[illegible]		[illegible]	[illegible]				[illegible]	1 [illegible]					
[illegible]		....do	40 00										
[illegible]		Labor						15 [illegible]					
[illegible]		Services	63 50									7 11	
[illegible]	171	Sheeting					25 00						
[illegible]	174	Towage						5 60					
11	179	Stone			1,040 60								
11	183	Labor										27 80	
11	184	Supplies			170 64								
11	188	....do			988 88		362 00						
7	194	Outfit					1,441 07	28 65					
11	195	Supplies			502 62								
11	196	Hardware			87 10								
11	197	Lamps			23 40								
11	198	Lumber			488 68								
11	199	File			5 88								
11	200	Wire			4,559 90								
11	216	Quarter-boats					8,000 00						
14	220	Supplies			483 62			5 70					
16	233	Barges					3,975 00						
16	234	Labor and material										8 13	
16	236	Supplies			7 75			2 67			105 71		
16	237	....do										10 60	
19	246	Hose					1,500 00	6 00					
5	249	Transportation						1 00					
23	253	Capstan					176 00	6 70					
23	254	Barge					1,250 00						
25	259	Bits						1 00	10 00				
25	260	Tools			82 00			1 12					
23	262	Transportation						75					
26	265	Tracing linen		$17 00									
26	270	Supplies			42 62			65					
22	273	Stone			990 00								
28	275	Services	50 00										
28	276	....do	31 25										
28	277	....do	50 00										
28	298	Ice-chests					24 00	2 85					
June 2	302	Services		28 00									
2	303	Towage						10 00					
4	308	Skiffs and oars					169 50						
4	314	Salt					84 56						
4	316	Napkins					15 90						
5	317	Supplies			820 10								
5	319	Rope			9 26								
5	320	Beef									725 00		
5	321	Winch-heads			53 76								
5	322	Labor						9 00					
5	324	Electric-light machinery					881 00						
5	325	....do					1,570 00						
5	328	Stone			1,358 28								
6	329	Labor and material										86 80	

Abstract of statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
June 7	330	Salt					$24 84						
7	332	Jack screws			$21 00			$0 60					
8	333	Supplies			36 00						$1,255 88		
8	334	do			38 17						184 64		
8	335	do			213 24			4 80					
8	339	do		$9 00									
7	340	Barge					1,250 00						
8	341	Travelling expenses	$6 40										
8	345	Labor and oil										$14 50	
8	346	Stone			239 85								
8	347	Salt					14 58						
4	348	Barges					5,200 00						
4	349	do					2,700 00						
8	357	Towage						10 00					
8	358	Labor, &c. (electric light)					108 85						
18	361	Mattress boats and barges					6,400 00						
18	365	Barge					1,250 00						
18	367	Salt						20 00			62 50		
18	369	Gauges			15 00								
18	370	Barges					2,600 00						
18	372	Towage						12 50					
18	374	Extract						65			66 30		
18	375	Stores and supplies			102 60			119 50			2,784 10		
18	381	Stationery		15 50									
18	382	Supplies			59 06			3 30					
18	383	do			999 18			16 05					
18	384	Drills			8 82			1 00					
18	385	Mosquito bars					45 28	50					
18	386	Fire tile and clay			22 10			3 85					
[illegible]	[illegible]	Hose bands			17 50			50					

	[illegible]	[illegible]	[illegible]arges					[illegible]					
	25	[illegible]	[illegible]alt					[illegible]					
	[illegible]	[illegible]	[illegible]ervices	[illegible] 00									
	[illegible]	[illegible]	......do	50 00									
	[illegible]	[illegible]	......do	25 00									
	[illegible]	[illegible]	Charter of steamer						[illegible] 00				
	25	[illegible]	Barge					1,250 00					
July	5	4	Traveling expenses	13 75									
	8	5	Hose			36 90						471 80		
	8	6	Supplies			2 25								
	8	10	......do			91 05								
	8	11	......do			135 90			34 45					
	5	19	......do			105 00			1 10					
	5	20	......do			16 20								
	6	30	Subsistence						7 45			77 84		
	6	31	Supplies			96 00			1 48					
	9	33	Towage						400 00					
	8	34	Stone			380 55								
	8	35	Services										8 20	
	9	37	Subsistence						4 26			87 83		
	9	40	Supplies			7 60			50					
	14	41	Barge					1,250 00						
	10	43	Ice									2,012 50		
	12	46	Supplies			82 50			2 40					
	13	50	Traveling expenses	7 25										
	14	53	Services										17 04	
	12	57	Mattress-boat					4,960 00						
	17	59	Supplies			16 74								
	17	60	Stone			270 27								
	18	61	Services										9 80	
	17	63	Barges					2,650 00						
	17	64	Labor and material			40 74				88 25			35 88	
	23	74	Subsistence						24 80			609 06		
	25	76	Supplies			65 00								
	25	77	Towage						450 00					
	24	79	Supplies			1,841 40			28 07					
	24	80	......do			20 00			50					
	25	81	Whitehall boats					380 00						
	25	83	Subsistence						12 53			238 60		
	27	85	Supplies			68 45			50					
	27	86	......do			69 50			1 00					
	27	88	......do			11 50			1 00					
	26	91	Towage						125 00					
	2	97	Traveling expenses	19 50										
	30	110	Supplies			12 15								
	31	116	Services	83 33										
	30	117	......do	50 00										
Aug.	1	118	Charter						542 50					
	2	123	Towage						27 50					
	2	124	Lumber					11 75						
	2	126	Services	50 00										

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Aug 3	129	Wire			$6,226 74								
3	132	Material and labor			921 71				$5 00			$12 60	
6	135	Traveling expenses	$17 60										
6	140	Mattress-boat					$4,200 00						
2	150	Labor (coaling)						$2 85					
9	155	Mattress-boat					5,400 00						
9	156	Material and labor			9 76				12 75				
10	162	Loading stores						7 79					
10	163	Medical supplies			14 00								
10	166	Stone			156 78								
10	167	Services										25 44	
13	168	Subsistence									$725 00		
13	169	Supplies			30 00								
13	171	Subsistence									35 70		
13	172	Supplies			2 50								
13	173	do			98 20								
13	175	Labor (loading stores)						23 75					
13	176	Subsistence									772 95		
13	178	Traveling expenses	3 50										
15	179	Supplies			700 34								
15	182	do			7 44								
15	183	do			18 75								
15	184	do			139 01						1,455 63		
15	187	Material and labor							8 16				
15	190	Stone			393 43								
16	193	Transportation						1 00					
16	194	Supplies			15 60								
16	195	do			122 83			1 00					
17	207	do			469 30								

[illegible]	[illegible]	Towage						8 60					
29	229	Skiffs			17 04								
29	235	Supplies			24 75								
29	236	Subsistence									35 70		
29	239	Superstructure (quarter boats)					880 00						
29	241	Supplies			394 10								
4	255	Traveling expenses	6 25										
4	257	......do	10 00										
4	259	......do	8 32										
4	260	Labor (loading stores)						3 00					
4	262	Transportation						1 55					
30	266	Subsistence									618 96		
30	269	Supplies			9 50								
30	271	Subsistence						4 90			24 50		
30	272	......do									303 96		
31	274	Services	50 00										
30	275	Labor (loading lumber)						4 50					
31	276	Services	50 00										
Sept. 3	282	Supplies			72 78						21 55		
3	284	Charter						543 50					
3	292	Labor and material							12 65			9 30	
4	294	Lumber			571 98								
1	297	Services	50 00										
7	314	Towage						25 00					
7	316	Labor and material							356 00				
7	320	Transportation						50					
6	324	......do						37					
10	329	Ice									1,407 00		
10	330	Labor and material							308 95				
12	340	Traveling expenses	5 00										
12	343	Stone			204 75								
12	344	Labor										10 96	
12	346	Charter						90 00					
13	348	Office supplies		6 85									
13	352	Supplies			24 00			1 00					
13	353	Rope			390 16			6 15					
13	355	Subsistence						1 00			37 02		
13	356	Coal				1,742 76							
17	357	Subsistence						20 82			791 24		
17	370	Services										2 80	
18	379	Traveling expenses	2 00										
19	382	Coal				16 50							
5	383	Stone			1,834 27								
5	384	Labor and material							47 20			21 60	
5	385	Transportation						210 00					
20	392	Wire			4 50								
21	396	Gauges			4 00								
25	408	Transportation						8 10					
28	423	Labor (loading stores)						5 00					

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883													
Sept. 30	424	Services	$50 00										
July 12	429	Hose			$194 20								
Sept. 30	437	......do			270 00			$1 00					
29	447	Services	50 00										
30	448	Charter						525 00					
30	449	Lumber			290 50								
Oct. 10	21	Labor										$5 40	
10	22	Stone			786 26								
10	23	Towage						150 00					
10	24	Service of steamer										54 00	
22	25	Subsistence						69 04			$1,455 90		
22	27	......do						8 80			486 38		
22	34	Towage						6 00					
22	37	Supplies			29 62			70					
22	40	......do			117 41			3 80					
22	45	Labor and material							$349 53				
22	46	Hardware			130 27								
22	47	......do			8 20								
22	48	Freight						2 54					
22	49	Sieves			2 33								
22	53	Outfit					$47 55						
22	54	......do					12 90	1 42					
22	56	Beef						37 12			725 00		
22	58	Subsistence						44 95			747 78		
20	61	Stationery		$38 35									
20	65	Lamps					72 00	4 50					
Sept. 29	83	Labor						2 00					

		Total	1,[illegible] 42	207 10	64,654 72	1,765 38	58,587 08	5,968 87	7,909 38	....	32,189 85	622 96	208,487 19

NEW MADRID REACH.

Capt. T. G. D. Knight.

1882.													
	91	Traveling expenses	30 10										
	181	Services	45 00										
	187	Stationery		8 00									
	198	Machinery					4,200 00						
Dec. 3	222	Barges					5,550 00						
	223	......do					9,245 00						
Dec. 2	230	Towage						715 00					
	237	Barges					9,750 00						
Dec. 7	243	Pile-driver leads					3,250 00						
9	353	Traveling expenses	15 00										
9	257	Services										12 00	
13	261	Pile-driver hulls					27,000 00						
11	262	Repairs						23 16					
18	272	Towage						350 00					
19	273	Barges					3,700 00						
20	275	Towage						60 00					
30	279	Services	87 50										
30	280	......do	25 00										
23	313	Traveling expenses	6,75										
1883.													
Jan. 2	1	Barges					5,400 00						
3	3	Pile-driver leads, &c					3,250 00	430 00					
2	4	Towage						25 00					
Feb. 6	17	Traveling expenses	11 75										
Jan. 8	25	......do	21 12										
15	26	Services										6 50	
15	33	Barges					15,600 00						
15	39	Traveling expenses	11 00										
16	40	Salt					76 25						
25	75	......do					52 65						
Feb. 7	115	Rope			$86 18			1 50					
5	116	Pumps					2,070 00						
Jan. 31	118	Services	95 00										
2	155	Barges (coal)					550 00						
Feb. 6	176	Barges					1,850 00						
6	177	......do					10,050 00						
6	178	......do					2,000 00						
12	182	Pumps					4,960 00						
12	197	Anchors					1,630 48						
20	207	Towage						160 00					
19	226	......do						10 00					

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

NEW MADRID REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Feb. 21	227	Hauling						36 00					
24	228	Hose			600 00								
Mar. 1	260	Barges					7,200 00						
2	276	Salt					98 55						
2	279	Pile-driver hulls and barges					5,950 00						
2	280	Traveling expenses	$5 00										
5	292	Pump					650 00						
6	293	Services	100 00										
8	311	Couplings					80 60						
9	312	Hose					100 00						
13	326	Barges					3,600 00						
26	361	do					1,800 00						
29	372	Machinery					9,295 25						
31	376	Services	75 00										
Apr. 6	9	Machinery					4,784 58						
9	32	Towage						60 00					
9	35	Machinery					4,794 68						
16	79	do					1,715 79						
9	98	Quarter-boats, barges, and pile-driver hulls					5,950 00						
18	105	Machinery					4,784 58						
21	124	do					5,839 15						
May 11	217	Pile-driver hulls					4,500 00						
11	218	Machinery					5,172 82						
11	219	do					4,782 88						
11	224	Traveling expenses	12 95										

1882.													
	91	Traveling expenses	$4 30										
	95	Towage						$150 00					
	108	Traveling expenses	10 95										
	181	Services	80 00										
	182	do	125 00										
	185	Boats					$13,500 60						
	187	Stationery		$2 00									
	198	Machinery					4,200 00						
Dec. 1	210	Rope			$552 97			11 70					
1	212	Subsistence						5 40			$82 80		
4	221	Stone			109 67								
4	227	Subsistence						8 50			225 98		
2	230	Barges					30,000 00						
5	233	Supplies			91 75			8 00					
7	242	Coal boat					1,200 00						
6	245	Rope			67 17								
8	250	Wire			1,248 10			60 89					
12	254	Towage						87 00					
	256	Traveling expenses	48 75										
Dec. 13	261	Screen-boats					4,500 00						
13	265	Spikes			343 20			25 80					
18	272	Towage						595 00					
16	274	Stone			112 00								
19	277	Barges					6,000 00						
30	280	Services	100 00										
30	281	do	125 00										
18	303	Rope			134 05								
4	309	Spikes			77 40			3 60					
1883.													
Jan. 2	1	Quarter-boats					1,200 00						
2	2	Barges					10,000 00						
8	14	do					5,880 00						
8	25	Traveling expenses	21 12										
15	26	Services										$6 50	
9	29	Services, pilot						50 00					
16	40	Salt					76 25						
15	45	Services, pilot						54 00					
29	46	Subsistence									351 74		
25	49	Skiffs					660 00						
17	57	Towage						5 00					
15	61	Traveling expenses	41 30										
25	65	Outfit					123 59	1 95					
5	67	Stone			302 75								
25	71	Outfit					130 16	1 70					
25	77	Subsistence									617 45		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

MEMPHIS REACH AND HARBOR—Continued.

Date.		Voucher number.	For what expended.	[illegible]	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and traveling expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.														
Jan.	25	78	Salt					$17 55						
	17	91	Travelling expenses						$94 00					
	27	111	Outfit					117 50	1 00					
	31	118	Services	$20 00										
	31	119	do	125 00										
	31	120	do	40 00										
	2	155	Coal barges					500 00						
Feb.	5	167	Travelling expenses	6 00										
	3	174	Services										$605 00	
	3	175	Stone			$104 04								
	6	177	Barges					8,020 00						
	12	179	Towage						45 00					
	12	180	Charter						465 00					
Jan.	25	183	Travelling expenses	8 00										
Feb.	13	184	Rope			111 00								
Jan.	16	193	Superstructure, quarter boat					1,041 00						
	31	194	do					1,176 00						
Feb.	6	196	Wire			9,010 00								
	15	200	Labor						8 00					
	20	207	Towage						200 00					
	14	208	Services										14 00	
Jan.	6	209	Travelling expenses	50 20										
Feb.	19	226	Towage						10 00					
	27	253	Services	20 00										
Mar.	2	274	Charter						490 00					
	2	280	Travelling expenses	1 25										
	6	203	Services	25 00										
	6	205	do	190 00										
	8	206	Towage											

	[illegible]	369	Pile-driver hulls					4,[illegible]						
	[illegible]	370	Anchors					[illegible] 78						
	31	374	Towage						10 00					
	31	376	Services	50 00										
	31	377	......do	50 00										
	31	380	Charter						465 00					
Apr.	6	13	Services						25 50					
	9	32	Towage						90 00					
	9	33	Pile-driver hulls					2,900 00						
	6	73	Labor										56 50	
	6	74	Stone			1,078 11								
	17	92	Pile-driver hulls					5,850 00						
	28	129	Pumping-boat					300 00						
	30	156	Services	45 00										
May	11	179	Stone			534 80								
	11	180	Labor										13 90	
	11	222	Charter						450 00					
	16	234	Labor and material										55 05	
	12	239	Pumps					4,160 00						
	22	273	Stone			495 00								
	28	275	Services	25 00										
	28	276	......do	62 50										
	28	277	......do	25 00										
	28	279	Charter						465 00					
June	2	303	Towage						5 00					
	4	314	Salt					17 28						
	5	328	Stone			679 14								
	5	329	Labor and material										48 40	
	7	330	Salt					12 42						
	8	341	Traveling expenses	8 20										
	8	345	Labor, &c										7 28	
	8	346	Stone			119 93								
	8	347	Salt					7 29						
	8	357	Towage						5 00					
	18	366	Labor							$16 00				
	21	394	Machinery					12,931 60						
	23	400	Extra work on plant					272 00						
	25	404	Salt					34 02						
	27	410	Labor and material					141 11						
	29	422	Services	25 00										
	29	423	......do	25 00										
	29	426	Charter						450 00					
July	3	34	Stone			190 29								
	3	35	Labor										4 10	
	14	53	......do										8 52	
	17	59	Salt			8 37								
	17	60	Stone			135 13								
	13	61	Labor										4 90	
	2	97	Traveling expenses	9 75										

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

MEMPHIS REACH AND HARBOR—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Aug. 1	119	Chartered						$465 00					
2	124	Lumber					$5 89						
2	126	Services	$25 00										
3	132	Stone			$460 86				$2 50			$6 30	
10	166	......do			78 39								
10	167	Labor										12 72	
15	187	Lumber							4 09				
15	190	Stone			196 71								
27	226	Towage						4 00					
4	259	Traveling expenses	4 16										
30	269	Paper			5 00								
31	274	Services	25 00										
31	276	......do	25 00										
Sept. 3	288	Charter						465 00					
3	292	Labor and material							6 33			4 60	
1	297	Services	25 00										
7	316	Labor and material							178 05				
12	340	Traveling expenses	2 50										
12	343	Stone			102 38								
12	344	Labor										5 48	
13	359	Labor and material							9 50				
17	370	Labor										1 40	
18	379	Traveling expenses	1 00										
5	383	Stone			917 14								
5	384	Labor and material							23 60			10 80	
5	385	Labor						105 00					
30	424	Services	25 00										
30	425	Charter						450 00					
[illegible]	447	Services	25 00										

Capt. W. L. MARSHALL.

1882.													
	95	Towage						175 00					
	149	......do						125 00					
	188	Services	104 17										
	196	Charter						495 00					
	204	Barge					2,000 00						
	205	Iron			161 76			18 30					
	207	Subsistence						30 50			382 15		
	208	Stores and supplies			125 06			96 37			1,517 04		
	209	......do			25 50			84 00			581 80		
	214	......do			24 24			43 00			647 27		
Dec. 6	245	Rope			67 17								
9	253	Traveling expenses	6 00										
12	258	Barge					2,000 00						
16	268	......do					2,000 00						
18	272	Towage						35 00					
18	276	Barge					2,000 00						
30	279	Services	87 50										
30	282	......do	125 00										
23	285	Traveling expenses	12 40										
30	288	Charter						465 00					
22	290	Loading stores						21 60					
22	291	Subsistence									148 82		
22	292	......do									17 25		
19	298	......do						6 00			197 14		
19	299	......do						11 00			246 90		
19	300	......do						11 00			237 50		
19	301	......do						14 74			540 00		
20	307	Stores and supplies			272 41			37 91			1,950 63		
23	313	Traveling expenses	15 75										
1883.													
Jan. 2	1	Barges, &c					2,400 00						
4	5	Barges					2,000 00						
6	8	Subsistence									58 75		
8	11	Barge					2,000 00						
6	12	......do					2,000 00						
Feb. 6	17	Traveling expenses	11 75										
Jan. 15	26	Services										6 50	
15	39	Traveling expenses	11 00										
16	40	Salt					76 25						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Jan. 16	41	Tow-boat Charlie De Pauw					$17,404 00						
15	45	Services, pilot						$18 00					
25	49	Skiffs					100 00						
16	52	Barges					2,000 00						
5	67	Stone			$666 50								
25	96	Oil			27 00								
25	98	Stores and supplies			53 29								
26	99	Beef									$465 47		
26	100	Flour									500 00		
26	101	Hams									115 00		
26	102	Subsistence									84 28		
26	105	Supplies			132 75						329 46		
27	109	....do			67 20						390 72		
27	113	....do			37 60						224 54		
31	117	Services	$125 00								1,255 88		
31	118	....do	5 00										
31	120	....do	30 00										
29	121	Supplies			5 25						355 90		
29	124	....do			20 25						528 76		
30	127	Subsistence									57 26		
30	134	Charter						435 00					
Feb. 3	140	Barges					2,000 00						
Jan. 30	143	Transportation						163 20					
Feb. 1	145	Flour									254 40		
2	160	Subsistence						61 80			518 85		
5	162	Barge					2,000 00						
3	168	Peas						85			14 00		
3	174	Services										$32 00	
3	175	Stone			1,634 49								
12	179	Towage						250 00					
[illegible]	[illegible]	Traveling expenses	7 00										

	[illegible]	[illegible]	[illegible] and repairs		[illegible]									
Mar.	1	[illegible]	Barges					[illegible]						
	1	[illegible]	Pontoons									[illegible]		
	1	[illegible]	Charter						[illegible] 00					
	1	[illegible]	Services	128 00										
	2	377	Towage						1,000 00					
	5	[illegible]	do						600 00					
	8	[illegible]	do						100 00					
	12	[illegible]	Stone			110 87								
	12	309	Material			47 50								
	8	310	Services	125 00										
Feb.	27	312	Stone			221 18								
Mar.	5	318	do			500 94								
	13	324	Labor										30 00	
	24	356	Books			5 50								
	26	361	Barges					2,400 00						
	24	366	Transportation						324 48					
	28	371	Anchors					110 97	6 56					
	31	377	Services	37 50										
	31	378	do	125 00										
	31	381	Charter						556 00					
	30	383	Services	62 50										
	31	384	Wire			7,218 72								
Apr.	2	5	Capstan					502 40						
	6	10	Traveling expenses	33 10										
	6	16	Labor						20 00					
	6	17	Traveling expenses	27 80										
	6	21	Subsistence									96 90		
	7	25	Towage						10 00					
	7	31	Services	16 67										
	10	44	Outfit					164 63						
	10	45	do					127 13						
	10	46	do					465 00						
	11	51	Ranges					372 40						
	11	52	Outfit					480 18						
	12	58	do					50 50	50					
	6	74	Stone			1,313 78								
	9	75	Traveling expenses	50 75										
	9	98	Plant					16,000 00						
	19	112	Outfit					1,080 20						
	19	113	Stone			234 00								
	20	116	Outfit					50 00						
	21	123	Services						10 00					
	23	128	Rope			116 39								
	23	129	Pumping boat					600 00						
	24	131	Ice-chests					110 00						
	26	135	Supplies						58 90			509 86		
	26	136	do						24 40			437 85		
	27	138	Wire			5,537 00								
	27	139	Outfit					30 15						
	27	140	Subsistence						15 15			174 44		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1880, to October 31, 1884, both inclusive—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.	Voucher number.	For what expended.	Administrative and engineering.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and traveling expenses.	Repairs.	[illegible]	Subsistence.	[illegible]	[illegible]
1883.													
Apr. 28	142	Supplies			$28 00			$14 90			$181 40		
28	143	Subsistence						21 40			104 48		
30	148	Charter						540 00					
30	155	Services	$62 50										
30	156	....do	40 00										
May 1	165	Labor						17 11				$7 80	
1	169	Services	62 50										
7	174	Towage						5 00					
11	179	Stone			1,049 60								
11	180	Labor										97 80	
11	220	Mattresses					$249 40						
11	221	Charter						874 00					
11	225	Anchors					204 61						
12	228	Towage						100 00					
12	229	Coal				$150 00							
16	233	Barges					3,075 00						
16	234	Labor and material										24 42	
16	237	Labor, &c										10 60	
17	240	Transportation						27 50					
23	254	Barge					1,250 00						
26	268	Supplies			117 25			104 55			3,006 83		
26	271	Beef						25 60			580 00		
21	272	Barge					1,300 00						
22	273	Stone			900 00								
28	275	Services	50 00										
28	276	....do	81 25										

	5	346	Stone			289 55								
	6	347	Salt					14 36						
	4	348	Barges					5,200 00						
	4	349	......do					2,700 00						
	6	357	Towage						10 00					
	18	364	Mattress boats and barges					18,300 00						
	18	368	Barges					1,250 00						
	18	370	......do					2,600 00						
	18	372	Towage						12 50					
	18	379	Transportation						10 10					
	7	389	Barges					5,308 00						
	18	390	......do					2,981 00						
	18	395	Labor (repairs)							$16 70				
	7	396	Barges					4,050 00						
	28	397	......do					3,920 00						
	23	398	Labor					10 00						
	25	404	Salt					68 04						
	27	408	Transportation						89 35					
	29	422	Services	50 00										
	29	423	......do	50 00										
	29	424	......do	25 00										
	29	425	Charter						510 00					
	29	428	Barge					1,250 00						
July	5	4	Traveling expenses	13 75										
	8	8	Stores and supplies			59 68			117 65			1,998 53		
	5	13	Subsistence						30 00			580 00		
	5	14	Flour						66 00			620 00		
	5	18	Subsistence						48 65			941 24		
	5	23	......do						1 00			50 00		
	7	27	Skiffs					202 50						
	9	33	Towage						400 00					
	3	34	Stone			380 55								
	3	35	Labor										8 20	
	10	36	Services										82 00	
	9	38	Supplies			2,210 00			49 25					
	14	41	Barge					1,200 00						
	18	50	Traveling expenses	7 25										
	14	53	Services										17 01	
	17	59	Supplies			16 74								
	17	60	Stone			270 27								
	13	61	Services										9 80	
	17	63	Plant					2,650 00						
	17	64	Labor and material			40 74				62 25			80 81	
	10	70	Transportation						10 10					
	25	77	Towage						450 00					
	27	90	Outfit					938 50						
	28	93	Flour						12 00			100 00		
	2	97	Traveling expenses	19 50										
	30	100	Subsistence									88 00		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
July 30	117	Services	$75 00										
Aug. 1	120	Charter						$527 00					
2	124	Lumber					$11 75						
2	126	Services	50 00										
3	132	Stone			$921 71				$5 00			$12 60	
6	135	Traveling expenses	17 60										
6	136	Subsistence						19 80			$435 00		
6	137	......do						34 45			1,029 63		
6	138	......do						41 00			1,078 65		
6	139	Supplies			19 75								
7	141	Labor and material							421 75				
6	142	Skiffs					204 00						
9	154	Barges					6,900 00						
9	156	Labor and material			9 76				12 75				
10	166	Stone			156 78								
10	167	Labor										25 44	
13	170	Labor and material							94 60				
13	178	Traveling expenses	3 50										
15	187	Material							8 16				
15	190	Stone			393 43								
17	203	Labor and material							175 13				
17	204	......do							4 65				
17	205	Services										78 00	
27	213	Material			10 00								
27	217	Meters					32 50						
27	218	Labor							25				
27	226	Towage						8 00					
29	229	Skiffs, &c			17 03								

			[illegible] and material							12 60			9 20	
			Labor						3 75					
	1		Services	50 00										
	7	315	Subsistence						30 10			3560 51		
	7	316	Labor and material							356 00				
	7	318	Subsistence						43 15			723 37		
	7	320	Transportation						50					
	7	324	......do						38					
	4	327	Subsistence									42 50		
	10	331	Labor and material							132 00				
	4	339	Pay roll (De Paw)						180 00					
	12	340	Traveling expenses	5 00								4		
	12	343	Stone			204 75								
	12	344	Labor										10 98	
	12	346	Charter						90 00					
	13	350	Labor and material							18 83				
	13	354	Supplies			7 00			1 00					
	14	360	Charter						358 63					
	17	368	Subsistence									185 42		
	17	369	......do									1 53		
	17	370	Labor										2 80	
	17	373	Subsistence									38 63		
	18	378	Supplies			260 60								
	18	379	Traveling expenses	2 00										
	5	383	Stone			1,834 27								
	5	384	Labor and material							47 30			21 60	
	5	385	Towage						210 00					
	18	386	Labor						1 50					
	19	387	Labor and material							61 82				
	20	391	Supplies			6 13								
	20	392	......do			4 50								
	22	398	Labor and material							610 61				
	22	401	Labor, coaling						10 00					
	22	402	Subsistence									4 50		
	24	404	Labor and material							128 00				
	25	405	......do							42 70				
	25	412	Transportation						15 50					
	25	413	Services, pilot						58 33					
	8	418	Labor							1 00				
	30	424	Services	50 00										
	30	426	Charter						510 00					
	30	433	Subsistence									40 45		
	30	434	Charter						525 00					
	30	435	Labor and material							133 81				
	30	441	Charter						870 00					
	30	443	Labor and material							108 38				
	29	447	Services	50 00										
Oct.	9	6	......do							5 00				
	5	11	Stone			5,115 60								
	10	21	Labor										5 40	

[illegible]	14	Labor, coaling									[illegible]		
2	15	Subsistence											
30	16	......do						76 47					
2	17	Labor, coaling						6 00					
Aug. 4	18	......do									7 50		
4	19	Subsistence						7 50					
4	20	Labor, coaling									6 65		
4	21	Subsistence									6 75		
4	22	......do									2 80		
4	23	......do											
17	24	Stationery		10 00									
17	25	Supplies			9 60						244 22		
27	26	Services										$6 00	
29	27	Furnace repairs							$40 00				
29	28	Repairs							14 00				
Sept. 4	29	......do							100 00				
4	30	......do							5 30				
13	31	Supplies			12 63			1 00					
13	32	Capstans					150 00	8 00					
13	33	Supplies			1,578 61			55 32					
13	34	Anchors					36 57	3 18					
5	35	Stone			300 96								
5	36	Poles and transportation			30 00			60 00					
5	37	Transportation						50 00					
28	38	Labor in transportation						5 00					
30	39	Wire			1,240 88								
Oct. 10	1	Stone			113 85								
22	2	Towage						550 00					
		Total	299 67	11 00	3,290 03	$000 00	24,460 97	846 47	159 30	$000 00	497 45	6 00	$29,570 89

MOUTH OF RED RIVER.

Maj. Amos Stickney.

1883.													
June 8	1	Hulls					$2,000 00						
18	2	Fire buckets					11 00						
23	3	Superstructure and tables					1,623 65						
23	4	Outfit					112 25						
23	5	......do					29 64						
23	6	......do					127 02						
23	7	Anchors					10 22						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

MOUTH OF RED RIVER—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
Jan. 23	8	Outfit					$284 12						
23	9	Furniture					92 60						
23	10	Services										$10 00	
23	11	Outfit					109 50						
25	12	Supplies			62 78						$243 99		
25	13	do			2 79						248 91		
25	14	Subsistence									16 00		
25	15	do									16 00		
25	16	Material and supplies			125 74								
25	17	do			129 47								
25	18	Skiffs					34 00						
Aug. 17	1	Stationery		$10 00									
Sept. 30	2	Coal				$614 62							
4	3	Subsistence									31 60		
4	4	Labor, coaling						$23 90					
4	5	Subsistence									6 00		
4	6	do									12 00		
Oct. 22	1	Supplies			16 38			24 20			304 10		
22	2	Subsistence						1 80			32 00		
15	3	Labor, coaling						4 00					
15	4	do						10 75					
15	5	do						6 85					
15	6	do						10 87					
		Total	$000 00	10 00	277 15	614 62	4,524 00	82 37	$000 00	$000 00	910 60	10 00	$6,428 74

APPENDIX I.

TAIN J. G. D. KNIGHT, CORPS OF ENGINEERS UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Cairo, Ill., November 27, 1883.

he following report is submitted in compliance with instructions of 383, to send immediately after October 31, 1883, a report of work done ds controlled by the Mississippi River Commission since the date of my ort and up to October 31, 1883.
levee location along the Saint Francis front; (2) the improvement of d Reach; and (3) the improvement of the Plum Point Reach.

SAINT FRANCIS FRONT.

, 1882, instructions were issued by the Commission that such surveys e of the Saint Francis front in the first district as would render it posto the Commission the cost of closing all gaps in the levee to the old at front; but no allotment out of which to pay the cost of such surveys l November 19, when $5,000 was allotted for the survey of so much of ıcis front as lies in the first district. Two days later the Commission ctions for the surveys of new levees.
vee that could be utilized in the construction of the new amounted, in :t, to but 1 per cent. of the volume of the entire work, instead of for ı the old levee, the required estimates were for virtually building a new s front; hence, the instructions of the Commission as to surveys for new cidedly applicable to this work.
r a small party was sent out to commence the location; but as it was ıt its instructions were not sufficiently comprehensive, and as fuller inessitated a differently organized party, the first was recalled.
ys and estimates could not be made in time for the last annual report, s deferred until after the high water. In the spring, propositions were various parties to make the required surveys at prices varying from r mile; and the lowest proposition, that of Civil Engineer H. N. Pharr, :., accepted. His party started out about June 1, 1883, from Bird's Point, ecuted the work with energy until it was stopped, in the bend above y high water. Resuming in July, Engineer Pharr carried on the locaıpletion. The level notes and profiles were received in September; the r passed without the plotted location coming to hand.
ximate estimate the following figures are given, to be followed by a rt when additional data are at hand:

to be leveed	miles	228.5
to be cleared	do	114.5
ire levee	cubic yards	9,000,000
levee available	do	90,000
th to be moved	do	8,910,000

earthwork at 25 cents per yard, clearing at $30 per acre—the number estimated as 750—and cost of surveying and inspection at $50,000, the cost of leveeing so much of the Saint Francis front as is in the first dis2,301,000.
: expended under the allotment is as follows:

and draughtsman	$3,069 36
stationery, and maps	226 05
ops	9 50
	8 00
	3,312 91

STATEMENT.

	$5,000 00
in above statement	3,312 91
e on hand November 1, 1883	1,687 09

[illegible] line is still to be run between Garfield and [illegible] made with reference to the [illegible] Southeast Missouri and Northeast Arkansas, this balance [illegible] liabilities incurred, or to be incurred.

NEW MADRID REACH.

The Commission recommended, August 18, 1882, that the [illegible] made for the New Madrid Reach [illegible] a project for the plant needed [illegible] Later I was informed that the survey [illegible] New Madrid Reach should include the river from the head of Island No. [illegible] a distance of [illegible] miles. August 18, 1882, an allotment of [illegible] reach.

The survey was commenced September 23, 1882, 1.5 miles above Island No. [illegible] completed during the following December, having been [illegible] Island No. [illegible] A map of the entire survey was [illegible]

[illegible] 1882, the following plant for this reach was recommended [illegible] Commission and approved by the Commission: [illegible] barges for stone and brush, one machine-shop boat, [illegible] mattress-boats, six one-hundred-foot mattress [illegible]

[illegible] 1882, [illegible] construction of plant already ordered was [illegible] for this reach was suspended; and on March [illegible] was transferred to the Plum Point allotment, and the balance [illegible] liabilities, ordered transferred to the Lake Providence [illegible]

[illegible] for the executive officer of the [illegible] twenty-five pile-drivers, one machine-shop [illegible] following table:

[illegible] executive officer, *Mississippi River Commission* [illegible] *for use on that reach.*

[illegible]	No.	[illegible]	Total cost.	Remarks.
[illegible]	[illegible]	[illegible]	$35,150 00	Of these barges, 15, [illegible] $32,045, are in use at Plum Point Reach, and 25, [illegible] at $42,100, in general [illegible] service.
[illegible]	[illegible]	[illegible]	9,245 00	
[illegible]	[illegible]	[illegible]	18,000 00	
[illegible]	[illegible]	[illegible]	8,750 00	
[illegible]	[illegible]	[illegible]	2,000 00	
[illegible]		[illegible]	8,130 00	In use at Plum Point.
[illegible]	[illegible]	[illegible]	108,317 00	5 in use at Plum Point [illegible] use at Lake Providence [illegible] laid up.
[illegible]			1,820 48	
[illegible]			237 45	
[illegible]			192,650 53	

[illegible] outfit, was $3,380.

[illegible] as follows:

[illegible]	Captain [illegible]	Captain Knight.	Tot[illegible]
[illegible]	[illegible]	....	[illegible]
[illegible]	[illegible]	....	[illegible]
[illegible]	[illegible]	....	[illegible]
[illegible]	[illegible]	....	193,5[illegible]
[illegible]	[illegible]	....	6,[illegible]
[illegible]		$4,496 95	4,[illegible]
[illegible]	[illegible]	....	[illegible]
[illegible]	[illegible]	....	3,8[illegible]
[illegible]	[illegible]	4,496 95	203,6[illegible]

STATEMENT.

otment		$700,000 00
nsferred to Plum Point allotment	$300,000 00	
nsferred to Lake Providence allotment	187,500 00	
bursed by Captain Sears	204,572 16	
bursed by Captain Knight	4,498 95	
		696,571 11
Balance		3,428 89
ance in hands of Captain Sears November 1		$2,427 84
ance in hands of Captain Knight November 1		1,001 05
		3,428 89

hough apparently it is not contemplated to begin work on the New Madrid Reach h any portion of the appropriations hitherto made, the still existing necessity of improvement of this reach cannot be doubted. During the low-water season just sed it has been marked by three of the most troublesome places between Cairo and nphis, viz: Phillip's Crossing, Point Pleasant, and Tiptonville. Shoal water and hous channel have characterized these places, and the latter vicinity has been rked by loss of property, delay of steamboats, and many channel changes. It will tinue to be so characterized until the extremely unstable banks from New Madrid Tiptonville be protected from the assaults of the river, and the channel otherwise d. The locality is an excellent one for a crucial test of any system of bank protion, much of the river bank being sandy and high.

hould the Commission consider the advisability of work of river improvement elsere than where already commenced, I would suggest this field as one where imvement is urgently demanded.

PLUM POINT REACH.

From December 19, 1882, to June 6, 1883, First Lieut. T. W. Symons, Corps of Eneers, was in local charge of work on this reach. On his accepting other duty, ited States Assistant Engineer A. J. Frith resumed charge, and has since retained it.

Since the date of my last report, additional dikes, shown on the maps of the reach nexed (Plates II–V), and as follows, have been ordered by the Commission: Two kes 1*a* and 1*b*, between dikes 1 and 2, at Gold Dust; dike 4, in Osceola Chute, and ke 2, in Bullerton Chute.

The dikes in course of construction at that date were those at Gold Dust—the main ke and cross-dikes 1 to 5—the Osceola middle, and Osceola-Bullerton. Later work the upper Osceola was resumed. Osceola cross No. 1 was commenced March, 1883; ceola cross No. 2, April, 1883; Osceola cross No. 3, March, 1883; Bullerton crossike No 1, June, 1883; Plum Point main dike and No. 1 cross-dike in September, 1883, d No. 2 cross-dike in October.

Of the dikes ordered or approved by the Commission, the following have not been mmenced: Osceola cross No. 4, Bullerton cross No. 2, and Plum Point cross Nos. 3, , and 5. Osceola cross-dike No. 4 was ordered June 30, 1883, but its construction uld not be carried on at low water. Bullerton cross-dike No. 2, ordered at the same me, could not be put in, as the attempt so to do would have interfered with the use f the only navigable channel near Bullerton Tow-head; the Plum Point dikes were ferred, as my project, in which they were incorporated, was approved subject to the oviso that they be not undertaken so long as the plant can be employed elsewhere. While projects submitted from time to time covered bank protection of the Tenssee shore from Ashport to Gold Dust, of the Arkansas shore from Mill Bayou to upper Osceola Chute, and from Bullerton Chute to Craighead Point, of upper and lower Osceola Bars, of Bullerton Tow-head, and Yankee Bar, to attempt to protect more than Bullerton tow-head has been found impracticable. That this should be protected was ecessary, as the bar in front continually crowded the water over, thus threatening e cutting in two of the tow-head; also as the river persisted in establishing for this ason the main channel in Bullerton Chute, there might have been much wearing ay at the head. Two thousand six hundred and ninety-four feet of mattress, withupper bank protection, were built at Ashport, and so far have served to prevent ving.

e following table shows the amount of work reported at each place and the amount ike actually standing, as shown by the reports of Assistants Gender, Marx, Nolty, Yeager (Appendices J 2–J 5) and the plates thereto annexed (Plates II–V). The rence between the two items serves as a basis for determining the total amount ork destroyed, not limited to the past year, and the estimated value thereof. se values are based on those given later in a table, showing the amount and cost all work on this reach:

Estimated value and quantity of damage done to works at Plum Point, Tennessee.

Construction at—	Pile-work, in linear feet.			Brush-work, in squares of 100 square feet.			Approximate value.
	Reported as constructed.	Reported as standing.	Number of feet lost.	Reported as constructed.	Estimated quantity in tact.	Estimated quantity lost.	
Plum Point dikes	901	901		814.80	814.80		
Bullerton:							
Tow-head bank protection				20,604.80	17,802.80	3,102.00	$24,850
Main dike	8,305	4,800	3,405	3,154.50	1,843.50	1,311.00	18,000
Cross dike	1,770	1,770		2,620.80	2,620.80		
Osceola:							
Upper bar bank protection				4,125.80	2,980.80	1,145.00	7,400
Lower bar bank protection				8,054.84	7,238.00	816.84	5,200
Upper dike	2,815	2,268	547	3,807.17	3,115.00	702.17	3,500
Middle dike	3,773	1,059	2,714	5,292.80	3,409.00	1,883.80	32,500
Cross dikes	6,987	4,570	2,417	3,020.06	2,718.29	301.77	28,200
Gold Dust dike	35,983	23,897	12,086	17,670.00	11,281.00	6,389.00	147,400
Ashport bank revetment				4,041.00	4,041.00		
Bullerton Tow-head bank protection	*2,400		2,400	*540.00		540.00	15,000
Osceola upper dike	*4,500		4,500	*570.00		570.00	
							302,100

NOTE.—The amount of brush-work reported as lost includes, in the case of dike work, such amount of mattress as had to be renewed on account of pile-dike giving way. Figures marked * represent work done previous to July 12, 1882, *i. e.*, previous to present appropriation.

age to the pile-work resulted from the weak forms of dike first used, from lete condition, and from irresistible scouring action of the river.

; work consisted of bents formed by pulling over and fastening at the tops ling piles of two parallel rows; 2,400 feet of this was removed by scour in e of a foot-mat. Later, dikes of piles braced by single inclined piles and al stringers were tried and found wanting; the one at Upper Osceola ing been almost wholly broken off, though not before it had induced much the head of the chute. Then was tried a form shown in my report of 1882, , as was shown by its experience with the high water of last spring. A planned by United States Assistant Engineer A. J. Frith, has been adopted ent, and will, it is thought, prove sufficiently strong.

om the dikes, even if finished, being too weak to resist the great strains to y have been subjected, there was the desire to take advantage of favorable rater, which resulted in the pile-work being hurried ahead too far in adts protecting mat-work; and when rising water came, there came with it drift, which, at the same time, both prevented mat construction and inr. Finally 2,500 of the 3,300 feet of Osceola middle dike were carried away rer suddenly scouring out a volume having a cross-section of 1,200 feet 20 depth. Even the foot-mat along its front failed to stay this scouring

to the bank protection has resulted from three causes: Chiefly, the atrork at too high stages of the river, in consequence of which the mattress er protection has, by rising water, been carried to the tops of banks and nded so high as to admit of undermining; secondarily, water seeping from ions in pools and above comparatively impermeable strata has induced rear of high-water protection; and in a very few cases the mattress or its ave been found too weak to bear the strain brought upon them by rapid

stion is naturally suggested, is a repetition of this great damage to be ex-

e-work, the answer is, no. The height of the tops of dikes having been s drift will accumulate against the dikes. A careful following up of pilebrush-work and mattressing of openings before closing them will diminish ility of scour. The increased strength given to dikes will increase their and equally beneficial results may be expected from a reliance on crossome cases where longitudinal have been used, as in the case of Osceola mid- Damage to this was exceptional in its cause, and how to guard against like ot yet known.

nk protection, loss may be avoided by abstaining from efforts to build a lowection during high stages, as then such work could only be done with any ccess along a bluff shore. Mattresses can also be strengthened to stand its so far experienced. Seepage water is more troublesome. Drainage of be attempted in favorable cases; but more likely the true remedy is an exflat slope above the line of exudation.

owing table gives, as nearly as it can be made from data in this office, the d cost of all work on this reach. The exceptionally high cost of Bullerlike No. 1 is due to deep and rapid water; that of the Plum Point dikes, the fact that much work thereon, being incomplete, can only be estimated.

uction of—	Labor in construction.	Material for construction.	Subsistence.	Repair and outfit of plant.	Care of property.	Steamer and towage.
dikes	$5,167 26	$5,416 11	$1,078 80	$7,954 00	$1,166 22	$3,615 28
kes	13,537 38	9,497 35	3,179 70	17,878 00	2,621 44	8,126 46
kes	19,859 59	15,876 60	5,371 50	28,036 00	4,110 77	12,743 38
d bank protec-	32,766 69	30,427 86	7,890 80	48,480 00	7,108 54	22,036 42
ar bank protec-	11,392 93	8,504 86	2,940 60	15,576 00	2,283 84	7,079 82
ar bank protec-	5,318 27	4,961 00	1,604 10	8,104 00	1,188 34	3,683 85
ike	9,437 90	9,850 63	2,234 80	14,674 00	2,152 34	6,670 00
like	10,260 52	8,955 10	2,406 90	14,740 00	2,162 25	6,703 00
kes	17,866 67	14,376 00	4,611 60	25,134 00	3,685 43	11,424 83
likes	85,280 05	79,680 53	18,019 50	128,992 94	18,013 65	55,460 46
ak protection	5,187 05	5,527 27	1,402 20	8,268 00	1,211 65	3,758 35
l	216,074 31	193,073 31	50,740 50	317,836 94	45,704 47	141,301 85

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

[illegible]

[illegible]

[illegible]

obably due to the contraction produced by the upper and lower sections of
-Bullerton dike. It is true that an effort was made to join these sections.
ffort met with success, it is believed that diverting a large portion of so
ly of water as that going through Bullerton Chute would not have failed
ilts at this crossing equally good with those obtained. In front of Buller-
ad there has been rather a redistribution of material than an increase of
w-water area; but this redistribution has been such that the deeper water
coincide with the desired new channel. When the Plum Point system of
re nearly completed, I can see no reason for doubting that there will be a
at least ten feet at low water in front of this towhead.
tely behind the Gold Dust main dike the bar crest has raised 10 feet,
om 12 to 25 feet above the level of the low water of 1879; the latter figure
on the first range above Elmot Bar, No. 31. The fill runs out to nothing
feet in rear of the dike.
ation of the results gained is rather premature. Over the greater portion
h the works are in too incomplete a state to be judged by results. Such
should be deferred at least until dikes in course of construction are com-
l the Arkansas shore from Mill Bayou to Osceola Chute, Osceola Bars, and
Towhead are revetted.
e given the works so far planned and still unexecuted, and an estimate of
their completion:

vetment, 19,600 feet, at $12	$235,200 00
revetment, 23,520 feet, at $12	282,240 00
rs revetment, 13,720 feet, at $12	164,640 00
r revetment, 7,840 feet, at $12	94,080 00
Point revetment, 15,000 feet, at $12	180,000 00
dikes, 10,300 feet, at $12.25	126,175 00
t dikes, 19,250 feet, at $12	231,000 00
o. 3 dike, 1,000 feet, at $12.25	12,250 00
No. 1 dike, 700 feet, $34.50	24,150 00
No. 2 dike, 1,000 feet, at $25	25,000 00
	1,374,735 00

roximate first cost of plant now employed at Plum Point is as follows:

		$48,000 00
-boats		58,320 00
s-boats		43,310 00
oat No. 1		5,200 00
oat No. 2		4,700 00
lic graders		60,464 00
ivers		62,300 00
ivers		10,640 00
ivers		9,240 00
hall boats		339 00
		536 50
		580 00
		300 00
oat		11,740 00
tug		9,500 00
launch (sunk)		3,200 00
launch		1,500 00
id from Plum Point allotment		329,869 50
ne-shop boat	$8,200 00	
rivers	26,625 00	
s	34,045 00	
id from New Madrid allotment		68,870 00
		398,739 50

STATEMENT.

ent from appropriation of March 3, 1881	$500,226 67
ent from appropriation of August 2, 1882	1,000,000 00
	1,500,226 67

Disbursed by Captain Quinn	$420,163 58	
Disbursed by Captain Sears	298,866 96	
Disbursed by Captain Knight	619,323 24	
Total disbursements to November 1, 1883		$1,338,[illegible]
Balance on hand November 1, 1883		161,[illegible]

This balance is accounted for as follows:

In the United States Treasury	$31,[illegible]
In the hands of Captain Sears	25,[illegible]
In the hands of Captain Knight	105,[illegible]
	161,[illegible]

The third of these balances had been reduced by November 26, 1883, to the f[illegible]ing amount, $51,180.51.

SUMMARY.

The following table shows all expenditures made for the first district Missi[illegible] River up to November 1, and also includes $22,319.45 of liabilities incurred:

PLUM POINT.												
Capts. Knight and Quinn	$8,544 76	$12,648 61	$44,969 97	$269,988 70	$110,665 34	$15,616 56	$128,898 45	$208,832 70	$122,560 64	$32,248 57	$13,738 48	$93,093 49
Capt. C. B. Sears	2,827 92	340 05	734 50	125,784 16	47,376 51	90 00	5,930 84	7,241 61	70,512 67			38,028 70
	11,372 68	12,988 66	45,704 47	395,772 86	158,041 85	15,706 56	134,829 29	216,074 31	193,073 31	32,248 57	13,738 48	131,122 19
NEW MADRID.												
Capt. J. G. D. Knight						4,498 95					3,833 25	
Capt. C. B. Sears	632 92	21 00	18 50	193,549 99	6,496 50		20 00					
	632 92	21 00	18 50	193,549 99	6,496 50	4,498 95	20 00				3,833 25	
SAINT FRANCIS.												
Capt. J. G. D. Knight						3,312 91						
Capt. C. B. Sears												
						3,312 91						

RECAPITULATION.

Plum Point	$11,372 68	$12,988 66	$45,704 47	$395,772 86	$158,041 85	$15,706 56	$134,829 29	$216,074 31	$193,073 31	$32,248 57	$13,738 48	$131,122 19
New Madrid	632 92	21 00	18 50	193,549 99	6,496 50	4,498 95	20 00				3,833 25	
Saint Francis						3,312 91						
	12,005 60	13,009 66	45,722 97	589,322 85	164,538 35	23,518 42	134,849 29	216,074 31	193,073 31	32,248 57	17,571,73	131,122 19

Total to October 31, 1883 .... $1,573,057 25

Very respectfully,

JOHN G. D. KNIGHT,
Captain of Engineers.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

t when deep water, varying strata, moving braces, fastening, and other encountered, twelve piles is a fair day's average.
vers are capable of being employed in 45 feet of water and considerable i efficient driving is difficult in water over 30 feet in depth and in violent

oats.—At the commencement of the year we had in all six mattress boats:
eet in length for 200-foot mattresses.
feet in length for 100-foot mattresses.
eet in length for 150-foot mattresses.
two are designed for mattresses with a wire base; the others for mat- s on poles. We have since received three boats 160 feet in length, also tresses. The design of these boats is not exactly similar but experience that the main requisites for the pole mattress are an ample platform on ite; ways with a slope of 1 foot in 3½ feet running close to the water, but ver the edge of the barge, also capstans at the ends for ready handling, l number of chocks and kevels for fastening lines.
ats.—There are now in service twelve quarter-boats, including that used d headquarters, and one for storing supplies. At the commencement a ing on an ordinary brush barge fulfilled all requirements, but the incon- nd discomforts of this form led to the building of the type now in use, and in s endeavored to combine all that is necessary for the health, comfort, and e employés. Most of these boats were built upon the works, and consist ual barge, the hull of which is used for kitchen, stores, and dining-room, ecks containing rooms for assistant in charge and foreman, and sleeping the men. These boats are provided with life line and floats, and buckets arrels to be used in case of fire, and accommodate 124 in all, including ks, and men.
·Two hydraulic graders, No. 2 and 4, have been allotted to work on this

ing the fore part of the year, was in use at Memphis, and was later held in ll on September 26, when about to be used in Elmot Chute, it was sunk l. It has since been raised, and is now in progress of repair.
, except during the high water, been in almost constant use during the ork done, being highly efficient and satisfactory.
lers are each fitted with three boilers 22 feet long by 40 inches diameter of e compound condensing pumps with 18 and 36 inch by 24 inch steam nd 16 by 24 inch water cylinders, and deliver 2,000 gallons a minute into boom, reaching up the bank, and from which lead the hose to the various zles. Two 1¼ and one 1¾ inch nozzles are ordinarily used, with pump 110 pounds and nozzle pressure of 80 pounds, the efficiency of water cylin- most 80 per cent. The woven cotton hose has proved in use, the most re- s grader has removed from 1,800 to 4,000 cubic yards of earth per day, at cost of 2.98 cents a yard, including wages, coal, subsistence, &c. Each ovided with electric lights for night work.
To supply material to various parties there are used fifty barges, 100 by 25 ne smaller barge, used for coal. Many of these, constructed with a view light brush, have broken down under the heavy willows generally fur- ose received later in the year and others altered here are better propor- ing 6-foot gunwales and two 4-inch fore-and-aft bulkheads, heavy head- bits, and carry 150 cords of brush or 200 cubic yards of rock. There are general-service barges some 30 by 120 foot barges carrying 330 cubic yards hese are, however, difficult to handle in heavy currents when sinking

METHODS OF CONSTRUCTION.

.—The dimensions of piling used during the year were increased over those accepted, by increasing the least size at the top to 8 inches from 6, the imit at the foot being 18 inches. Cottonwood piles form the bulk of the ed, though considerable cypress has been received. The piling was re- ifts landed at points above the localities where each piece of work was in nd, when practicable, dropped in small sections to the drivers; if not, boat loaded 100 to 140 of them on barges which were towed to conveni- ts for sorting and distribution.
section of dikes used in the early months of the year is shown in Plate VI, ing of 7½ feet between each truss. As a considerable portion of this ved, with your permission I undertook an investigation to determine which should combine an equality of resistance coupled with economy s liberal factor of safety, and of proportions that could be maintained water. The difficulty of determining exact data for these calculations quiry into the whole subject; still it is believed that the form chosen

...ance, in varying depths of water the ...
... destruction of each member ...
... pile by the pressure of the water ...
... straction to replace the wire ...
... easy coupling of the short rods ...

... stable soil in which the dikes are ...
... one of the most difficult obstacles ...
... of the dike seems to be alone ca...
... resses used during the first mont...
... has passed completely under ...
... layers of brush at right angles, held toge...
... through, the whole being sunk betwee...
... of the dikes, have not lately been ...
... as shown in Fig. 3, A being the grillage, an...
... of the footmat in all but main dikes.
... grillage thus arranged at Gold Dust this sy...
... part a curtain, has been made from 30 to 1...
... long, the inclined portion being supported on piling
... tendency to throw the current upwards, thus ind...
... B which will, it is believed, increase in a manner
... further advantage of following up a scour with all
... while the tipped grilliage in the rear prevents a des...
...

... scouring action of drift, experienced with portions ...
... kes are now built up to the 15-foot stage, rising to
... which are guarded against scour by thorough mat...
... (Fig. 4). On high dikes, an immense accum...
... which rendered all work at this stage during ...
... unsatisfactory.
... stage an extra row of piles should be driven
... until mattresses, &c., are completed, afte...
... it is not considered as part of the di...
... so much the actual pressure which is ...
... believed, but that the accumulat...
... discharge and causes a scour below ...
... the structure. If this scour can be g...
... resistance to the current, and in the ...
... is 600 feet wide by 1,200 feet lo...
... only from resistance to the flow o...

Several methods of constructing mattresses have been followed, governed by their alities and the work they were expected to perform.

They may be classified as follows:

1st. Shore mattress for the protection of the banks.

2d. Revetment, or protection of high-water slopes.

3d. Foot mattress, for protection of dikes.

4th. Tipped mattress.

5th. Grillage mattress.

1st. Shore mattresses for the protection of caving banks have been made in widths rying from 100 to 150 feet and lengths governed by the difficulties in sinking. When particular danger is to be anticipated, this mattress may be continuous to almost y length. Two varieties have been in use: 1st, that used by Major Ernst below int Louis, where the willows are woven on poles, preferably of sycamore, 7 to 8 et apart, Plate VII, Fig. 5, and forming a stiff and strong mattress, of which 170 et a day have been made with light brush and under favorable circumstances. This attress is easy of construction and has been mostly used during the year.

2d. There has also been used along the face of Bullerton a 100-foot mattress woven a wire base, the willows being interlaced, as shown in Plate VII, Fig. 6, forming mattress which is extremely pliable and hence more easily sunk. It is not so easily nstructed as the first, but a slightly greater average length a day has been obtained. The majority of brush furnished lately has, unfortunately, been too large and heavy obtain the best results.

As the shore mattresses are made they are guyed to the shore by 1½ to 2 inch lines, hich are removed as they are sunk.

The mattresses are fastened to the shore by wire cables or wires at frequent inter- ls and, when necessary, piles have been driven through the mattress to prevent any ovement.

When a stretch of mattress 1,000 or more feet in length is to be sunk, great care ust be used. In light currents the most rapid and easiest method (Plate VII, Fig.) is to commence sinking at the head, keeping the inner side of the mattress sunk a le in advance, and carefully sounding to see that it does not rise after the force of e current is removed. It will be perceived that the weak point is in the corner (A) ere the sharp bend tends to break the poles or willows, and where there is nothing resist the downward pull of the current but the flotation of the mattress.

When the water is very rapid it has been our practice to commence sinking at the er end (Plate VII, Fig. 8) where the shore side is also kept sunk a little ahead. is necessitates the drawing of stone barges up stream, which even in the slack- ter behind the mattress is troublesome and takes much time; still it has proved h the safer method, as there is little chance of sharp bends and broken willows the loss by collapsing of an entire mattress from a single accident. It is believed t with this method, when the mattress is made sufficiently strong, especially on e outer edge, and has been sufficiently guyed, that a collapse or entire loss is simply ossible. In October, 1883, on Bullerton 1,800 feet of mattress were sunk in 40 t of water with a five-mile current. This mattress was built on a netting formed wire cables such as were used on the dikes; still, at first, it proved too light and ks, yet but 75 running feet were lost. It was then strengthened until we had e cables on the outer edge and extra poles and wire on the outer 50 feet, when it s sunk in place in perfect shape without difficulty.

We have been extremely fortunate in sinking, and except when a mattress was torn lly from its fastenings by drift at high water, but very little has been lost. Great e, however, is always necessary to see that the rock is uniformly distributed, and t the mattress is thoroughly down in every part.

Our mattresses have averaged from one-half to three-fourths of a cord of brush to 100 square feet, which is sunk with from three-fourths to one and one-fourth cubic ds of rock, more being necessary with the second method of sinking than with first.

2d. Revetment for the protection of high-water bank, which should previously graded to the required slope, is composed of a frame of stout poles with 12 to 15 squares (Fig. 4) well wired at the intersections; over this a heavy layer of brush placed, then a second frame on top, the whole being sewed and wired through and ugh. This is to form a base for a covering of rock placed almost in juxtaposition, ugh frequently we have been obliged to content ourselves with just sufficient rock keep brush in place. The great enemy of a revetment is the flow of subsoil water m the bank; the drainage of low lands in the rear has greatly lessened this evil.

Foot mattresses placed at the foot of pile dikes have been made from 50 to 100 wide, and in construction do not differ from those made for protection of the bank. are easily sunk even in rapid currents, by starting at the head and keeping the s of the mattress in the general direction of the current.

4th and 5th. Tipped and grillage mattresses have already been thoroughly discussed er the head of dikes. To sink the former in heavy currents, especially when the

direction of the dike is across the flow of the most rapid water, they have been made in short sections thoroughly fastened with lines, and the inner edge sunk until the supporting wires are in tension when the stiffness of the mattress allows the outer edge to go down without much trouble.

QUARTERING AND SUBSISTING OF MEN.

With the large force of laborers employed, it became necessary to attend to the comfort, health, and safety of the men, and it is believed that the form of quarter-boat already mentioned meets all that is required without unnecessary expense.

These boats are used exclusively by the mattress parties, each quartering from 100 to [illegible] men in all, who are provided with, and held responsible for, mattresses and bedding. Bread, fresh meat, and ice are delivered by the tow-boats each day, and general stores every 15 days on requisitions of the boarding masters in charge, who also furnish each month an account of the amount used, number of meals furnished, &c., from which the cost of a ration is deduced. This has averaged about 29 cents for the raw and 4[illegible]½ cents for the cooked ration for one man each day.

Each pile-driver has quarters for its foremen and crew, while every fifth driver has extra accommodations for kitchen, dining-room, and fleet foremen, and can furnish meals for fifty men.

A bakery was built at Plum Point to furnish 400 to 500 loaves of fresh bread a day, but will soon be transferred to floating quarters as more convenient during the higher stage of the river.

Very respectfully, your obedient servant,

ARTHUR J. FRITH,
United States Assistant Engineer in charge.

CAPT. JOHN G. D. KNIGHT,
Corps of Engineers.

I 2.

REPORT OF GEORGE W. GENDER, ASSISTANT ENGINEER, UPON OPERATIONS AT GOLD DUST, TENNESSEE.

GOLD DUST, TENN., *October* 31, 1883.

CAPTAIN: I have the honor to submit to you the following report of operations at Gold Dust, Tenn., from December 1, 1882, to October 31, 1883:

The present condition of the work at this point is represented on the sketch forwarded with this report, Plate III; also the total amount of construction completed, [illegible] of which are placed upon the sketch. Stations were established every 100 feet [illegible] the work to.

Operations at this locality were in progress on the 1st of December, 1882, and continued up to this writing with such interruptions only as were made necessary by [illegible] stages of water. This year has been remarkable for its protracted period of high water, which divided the year into two distinct working seasons.

The work done at this point previous to December 1, 1882, consisted of a main dike [illegible] feet long, from Station 47 to Station 99.

On December 1, 1882, a force of men, with their quarters and a complete outfit for constructing mattress, was transferred from Ashport to Gold Dust, and the construction of a mat [illegible] feet wide, placed directly in front of the main dike, was begun.

Two small mattress boats, each 100 feet long, were used; one, commencing at the upstream end of the main dike at Station 97+57, constructing a continuous mat [illegible] feet long, and the other, beginning near the middle at Station 74, constructing a continuous mat 2,[illegible]61 feet long, which extended to the lower end of the dike.

On the [illegible]th of December a fleet of 10 pile-drivers arrived and commenced driving on Cross Dikes Nos. 1 and 2. During the first ten days of January this fleet was increased to 17 pile-drivers. These dikes were constructed after the improved form introduced by order of Mr. A. J. Frith, assistant engineer in charge, and consisted of two rows of piles 14 feet apart, with piles in each row spaced 7½ feet between centers. Longitudinal riders were placed on the entire length of both rows, secured to the piling by drift-bolts and wire. The two rows were joined by horizontal braces placed in the direction of the current as near as might be, and resting on the riders of both rows. They were drift-bolted and wired to pile and rider. This construction was strengthened by wire cables, consisting of six strands of No. 8 wire, which were fastened to the piles in the front row 16 feet (required penetration) above the lower end of the pile, and around pile, brace, and rider of the rear row.

After Cross Dikes Nos. 1 and 2 had been completed, with the exception of a passage way for barges and material, the river began rising. In order that piles might be driven over that portion of Elmot Bar, which was exposed at low stages, pile-drivers were moved to the bar end of Cross Dikes Nos. 3, 4, and 5. The water continued to [illegible] and soon submerged the dikes when operations were necessarily suspended, February 21, with the river at a 30-foot stage. The force was reduced and pile-drivers

ed to Plumb Point to make necessary repairs and alterations for better con- of work.

g the time of operations 4,899 linear feet of dike were driven. There were structed 4,664 linear feet of footmat 100 feet wide at the main dike, 738 linear et wide at Cross Dike No. 1, and 1,270 linear feet of footmat 50 feet wide at ke No. 2. The largest amount of footmat constructed in any one day on one boat was 251 linear feet. Wattling 10 feet wide was placed on the main its entire length.

the water began rising there were 2,420 linear feet of footmat on the surface ater and no stone could be procured.

lower end of the main dike 412 linear feet were still afloat. Quantities of wded beneath the mat, increasing the current under the mat to such an extent used a deep scour at the piles. As soon as this scour was noticed sacks were but before these were filled, loaded, and towed in place, this portion of the s scoured out and the accumulated raft, consisting of dike mat, and drift ng down-stream struck Cross Dike No. 3, which was temporarily able to re- great pressure, but being unprotected by a footmat, after several days a por- t scoured out.

ass of drift, driven by the swift current, struck Cross Dike No. 4 with irre- orce, demolishing a portion of that dyke.

s Dike No. 1, 738 linear feet of footmat, and at Cross Dike No. 2, 1,270 linear otmat 50 feet wide were still afloat, and the sand bags were used on these with By this time the dikes were entirely submerged, and the mats were anchored fastened to the piles. Sinking was done from skiffs, as the drift above and below the mat prevented the use of barges. Sinking was very difficult, as nt was at right angles to the line of the dike, and therefore had a tendency the up-stream edge under or over. The mat being driven down-stream by and current, the lower edge necessarily landed on the front piling, where it after the up-stream edge was sunk.

ount of the accumulation of drift in front of the main dike, work on foot- to be suspended before the upper section was completed, leaving the main rotected from Station 74 to Station 79+60. The river at this time was at a age, rising at the rate of one foot per day, and carrying heavy masses of its efforts to follow the more direct channel through Elmot Chute the cur- te through the main dike where it was unprotected by footmat at Station 75, mass of drift took out a portion of Cross Dike No. 2, represented on sketch tters *a b*.

ter rushing through this gap with a velocity of not less than 5 miles per hour, ing heavy masses of drift which struck the edges of the breach, breaking pile , soon increased the length of the breach, which was again increased during d rise. The gap in Cross Dyke No. 2 was not increased, the dyke being 10 r than the main dike.

mpt was made to repair these gaps, as the dikes were submerged.

ing an examination of the works at a low stage of water, it was found that dike had been damaged to a greater or less extent from Station 77+50 to 5+50, and from Station 59+60 to Station 47. That portion of the main dike upper breach was found uninjured, with the exception of a few riders and hich were crushed by the weight of drift resting on them after the water n.

gh the water was 7 feet above the tops of the piles the drift did not pass over and at some places it is 60 feet wide and solid to the bottom.

the dike was not protected by footmat small channels formed, having suffi- ocity to erode the bed.

Dike No. 1 remained intact, and has a deposit in its rear as high as the dike laces.

t-mat in front of that portion of the main dike which was carried away re- uninjured, and is covered for its entire length with large gravel, although a scour of several feet on both sides of it. The new dike has since been rough this foot-mat.

ater portion of the damage done to these dikes was due to the sudden rise rer before the work could be completed; nevertheless large deposits were hin the area that would be inclosed by the work when finished.

main dike the deposits formed immediately behind the dike, while at the s the material was deposited some distance below the dikes, and nearly to f the piles.

s Dike No. 2, where the lower edge of the foot-mat rested upon the dike, the rmed immediately under the mat and does not extend for any distance be- ike. This deposit consists of large gravel. The success of this accidental ion suggested the building of similar structures in hopes of obtaining like

il 16, with the river at a 28.35-foot stage, work was resumed and was con-

[illegible] with a force which was increased and decreased as the stage of the water be [illegible] of material in the work.

The eastern end of Elmot Bar being submerged, advantage was taken of the hig[h] stage of water to extend the western end of the main dike and northern end of Cro[ss] Dike No. [illegible] their junction with the main dike. The construction of the[se] [illegible] pushed forward [illegible], employing four pile-drivers on each of the ma[in] [illegible]. The [illegible] Nos. [illegible], 21, and [illegible] stationed at the main di[ke] were new and were a [illegible] improvement on the old ones. The height of the lead[s] being increased to [illegible] feet, allowed the greater portion of the piles to come under th[e] hammer [illegible] them into the water; while with the old leads, which had [illegible] feet, at a low stage of the river piles had to penetrate for several feet b[e]fore they could be brought under the hammer. The new drivers were also equippe[d] with large [illegible] compound duplex steam pumps, having two 10-inch and tw[o] [illegible] cylinders. The old drivers were equipped with single-acting piston pum[ps] having [illegible] cylinder.

At this point driving has been exceedingly difficult on account of layers of ve[ry] coarse gravel and [illegible] clay. Pieces of gravel weighing half a pound have frequentl[y] been [illegible].

At some places piles had to be pointed and driven, as the 1¼-inch jet of the o[ld] drivers was unable to displace the coarse gravel. The new drivers using a two-in[ch] jet were able to work through these hard strata without pointing the piles, but n[ot] without a liberal use of the hammer. As soon as the piles had passed through t[he] hard layers they would sink to the required depth of 16 feet with little difficulty.

About the 1st of May the construction of a grillage mat between the two rows [of] piles, and extending about 10 feet in front of the dike, was begun at Cross Dike No. [illegible] Sections of mat 60 by 35 feet were constructed, and consisted of a thick, coarse bru[sh] lying in the direction of the current, firmly lashed to a grillage of poles which w[as] suspended about 1 foot above the surface of the water by wires fastened to the brac[es] of the dike. As soon as a section was completed the wires were taken off and it w[as] sunk to the bottom with stones. These sections overlap about 7 feet.

A foot mat 100 feet wide placed directly in front of the main dike was commence[d] at Station 21−25; but work had to be suspended after completing 164 linear feet, [on] account of the drift accumulating in front of the dike, making it almost impossi[ble] to move the mattress boat.

Work on these lines was carried on until about the 1st of June, when they we[re] compelled to desist on account of the high stage of the water.

While the work of extending these lines was thus delayed, eight pile-drivers we[re] moved to Cross Dike No. 5 and its construction pushed forward. Four pile-drive[rs] were transferred to Bullerton.

From April 16 to June 1 there were driven 5,200 linear feet on the main dike, 1,[illegible] linear feet on Cross Dike No. 3, and 2,800 linear feet on Cross Dike No. 4. There we[re] also placed 2,200 linear feet of grillage 40 feet wide on the main dike, 1,600 line[ar] feet 35 feet wide on Cross Dike No. 4, and 850 linear feet 35 feet wide on Cross Di[ke] No. 3. Wattling 6 feet high was placed on the main dike for 800 linear feet, on Cr[oss] Dike No. 3 for 800 linear feet, and on Cross Dike No. 4 for 1,020 linear feet.

During the unexpected rise considerable damage was done to the main dike abo[ve] Station 36 and to the south end of Cross Dike No. 3, which was due to the unfinish[ed] condition of these lines.

After the water had fallen it was found that the portion of Cross Dike No. 3 lyi[ng] south of Station 8+50, the end of the grillage, was damaged to a greater or less exte[nt] by the piles scouring out and by the inability to secure the diagonal cables before t[he] dike was submerged, the intention being to secure them after the grillage was co[n]structed and sunk. A breach of about 100 feet was discovered above Station 36 [in] the main dike and one from Station 43+50 to Station 51.

The pieces of dike which had been scoured out floated down to Cross Dikes Nos. [4] and 5, and the piles are there being utilized to support the tip-mat. All of the piles were scoured out, as none were found broken. During the rise large deposi[ts] formed immediately in the rear of the main dike.

A bar whose crest became dry when the river fell to a 26-foot stage extended nea[rly] the whole length of the main dike below the lower breach. The largest deposits we[re] made at the junction of Cross Dikes Nos. 3 and 4 and the main dike.

The point of Elmot Bar, lying to the northward of the main dike, within the spa[ce] allotted to the channel, was washed away during this rise, and deposited in the re[ar] of the main dike. This point previously caused a large percentage of water to pa[ss] through Elmot Chute, thereby increasing the pressure on the dikes during high stag[es] of the river.

At the outer edge of the foot-mat on the main dike a scour has been noticed for t[he] entire length of the concave portion.

It was noticed that where drift had accumulated in front of the cross dikes a sco[ur] has taken place equal in volume to that of the drift, and that after the water had b[een] the bar the drift would exactly fill the space scoured out.

ater having fallen, operations were first resumed upon the gap in the main Station 36, and upon Cross Dike No. 3, at Station 8+50. The main dike ngthened wherever small channels were discovered passing through it, by clusters of two piles in the front row, and also a third row. The piles in the d second rows were supplied with cables which were fastened around pile, d brace of the third row, to conform to the "Standard Dike," at this time in- by Mr. A. J. Frith.

le-drivers were able to complete all dikes before the water left the bar, but ress work was delayed by inability to obtain material owing to the flooding illow camps. Grillage and wattling is now being completed on dry land, the y brush being supplied from the head of Elmot Bar.

e the transportation of rock across the dry bar, tarred sacks filled with gravel l are being substituted.

ortion of the main dike which was driven before the 1st of December, 1882, strengthened by driving two rows of piles in front of it and using the old hird row. Considerable difficulty was experienced driving through the old , which was covered with coarse gravel.

ortion of the dike is being protected by a tip-mat from 38 to 60 feet wide, ted in sections of 150 feet. The mattress boat is placed parallel to the dike, ion of the ways extending over the gunwale of the barge having been taken es are evenly distributed over the ways and their lower ends firmly secured les of the dike. The brush is wattled upon the poles by passing a rod of it ly above and below them. The mat is strengthened by placing poles above ath the wattling pole, firmly lashing them with No. 12 wire. A section of having been completed, the mattress boat is sparred from under the mat, and ream edge sunk to the bottom.

deep channel near the Tennessee shore a tip-mat 75 feet wide is being con- in front of Cross Dikes Nos. 3, 4, and 5. The mattress boat is placed at right the dike, the ways nearest the dike having been raised to the level of the maintain the mat at that height after it is launched from the mattress boat. nching the mat, piles are floated under it. The up-stream ends of these are the poles of the mat, and the down-stream ends raised to the level of the here they are drift-bolted and wired to the piles of the dike. The up-stream e mat is then sunk to the bottom. In swift currents this mat is constructed s 130 feet long, about the length of a rock barge, as the mat has to sink for length simultaneously to prevent the up-stream edge from doubling over or

the main dike and cross dikes strike the Tennessee shore, the bank has been l by a mattress 350 feet long, and varying in width from 50 to 100 feet. The re completed to this mattress, leaving a mattressed opening for navigation 0 feet wide. The bank at these places has been graded, and bank pro- being placed.

g was done with pile-driver No. 19, which is equipped with a Worthington d duplex pump, having two 10-inch and two 16-inch cylinders. The dis- bout 420 gallons per minute, passes first through a 4-inch pipe, then through hose, and is delivered through a $1\frac{1}{4}$-inch nozzle.

Table giving length of completed work as represented on sketch.

Dikes.	Number of linear feet of dike.	Number of linear feet of grillage or old foot-mat.	Number of linear feet of wattling.	Number of linear feet of tip-mat.	Number of linear feet of grading.	Number of linear feet of bank protection.	Number of linear feet of mattress.
....	9,457	8,311	1,600	1,325	....	410	350
No. 1	700	200	....	....	....	....	....
No. 1a	630	225	....	....	....	....	....
No. 1b	200	....	....	....	....	....	....
No. 2	700	350	....	....	....	....	....
No. 3	2,910	2,810	850	....	320	....	303
No. 4	4,400	2,630	1,020	300	350	....	340
No. 5	3,400	3,100	450	1,505	....	....	....
....	22,397	17,626	3,920	3,130	670	410	993

y respectfully, your obedient servant,

GEO. W. GEUDER,
United States Assistant Engineer.

G. D. KNIGHT,
Engineers, U. S. A., Cairo, Ill.

... UPPER DIKE.

... as built previous ... within the scene of ... fore be ... direction from ... Osceola Bar ... inclined struts ... to close in April ... piles, 14 feet apart ... swift current ... abandoned, and ... protected ... high water last ... is considered ... breaks, which ... scouring action in ... out of the ... shallow water have ... The foot-mat, as ... is still in place; ... place in front of th ... though it stood ... higher behind those ... of this fill is al ... further on, it may b ... a fair one. ... construction, a fau ... lack of previo

OSCEOLA ... No. 1.

... impossible to connect ... end of Osceola Up ... dike further down ... protected an ... braced piles ... base equ ... During the construction ... the dike drift ... the foot of the ... immediately s ... of the dike occurred ... the dike had to be changed ... driving. Luckily the material scoured out

piece of wire-united willow matting about 8 feet square was made. The wrapped up in it, and the center and ends of this bundle firmly wired. In case bailed rock was tied to willow bundles 6 to 8 feet long, and 1 to 1½ feet r. It was found by inspection, after the high water went down, tha the of fascines mentioned had done the better service of the two. They gener-directly in place, while the bailed rock of the second kind, catching on the cables, prevented the fascine from going to the bottom.

Secondary No. 1, which stood the high water well, is especially remarkable e amount of drift gathered in front of it. For a time the whole head of from the dike up, was filled completely. Winds blew some of the drift it had become firmly packed; but even to date about twenty acres of it osely wedged. Of course this mass has not been without its marked effect. drift first began collecting an increased tendency to scour in front of the noticed. The depth of this scour, as might be supposed, was equal to the of drift at the point under consideration. Where it has been possible the opening has been closed by sinking the drift, a barge of rock being expended bet for this purpose in front of Secondary No. 1. Should sinking the drift cases prove impossible, the scouring out of a dike is to be feared, unless it well protected by foot-mats.

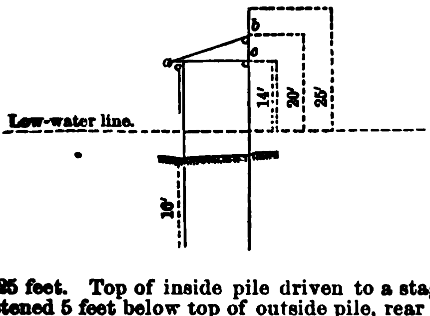
vil effect of the drift, cited above, a good one can be opposed. When the on of the dike was first begun quite a strong current set through the chute. ting drift checked it so completely that when the present amount had come rent was almost dead. A marked fill both in front and behind the dike has e, so that if the holding of the latter should prove successful the direction work would seem to be indicated.

OSCEOLA SECONDARY NO. 2.

struction of these dikes was pushed at the same time that No. 1 was build-first section extends from the Arkansas shore to the northern point of the the second section, from the lower end of this same towhead to the foot of pper Bar. The type adapted is the double-line, rectangular, 14-foot base pt for the southeastern end of Section 1 and the northeastern end of Sec-hese portions of the dike running up on high ground, it was deemed suffi-uild them of but a single line of piles. In the second section an opening length had to be left to enable the boats to reach the parties at work at hen the water began falling it fell so rapidly that the pile-drivers had to be ; before the gap could be closed. With the exception of this piece, then, inear feet of dike are protected by a grillage foot-mat and by wattling. pril 10 and finished May 20, these dikes have passed safely through one r; but built under the shelter of No. 1, little strain has come on them from her causes. A slight fill has taken place behind both of the dikes.

OSCEOLA MIDDLE DIKE.

Middle Dike, connecting the foot of Osceola Upper with the head of Osceola r was begun November 1, 1882. During December 1,065 linear feet were he part previously completed, giving the whole structure a length of 3,309 form of the dike adopted was the one as shown here. Top of outside pile



stage of 25 feet. Top of inside pile driven to a stage of 14 feet. Front rider fastened 5 feet below top of outside pile, rear rider at top of inside ined brace a b, horizontal a c; width of base, 14 feet. A 100-foot mattress he whole length of the dike and the latter also wattled. As the water rose o lower front fore-and-aft rider it became impossible to push the wattling em. It would have been better had it therefore been left out entirely, for

the water coming through the chute was pressed through the narrowed opening between the bottom and the lower sides, contributing its share to the strong scour already taking place in front of the dike. The 100-foot mat did not prove sufficient protection in this case, for in February the first break near the center of the dike, and undoubtedly caused by scouring, occurred. Toward the latter part of March pieces of the end sections followed, carried away by drift. An attempt made in May to patch the dike and to strengthen it by two little spur dikes proved unsuccessful. The cause of the failure of this structure, of which to date only 1,469 linear feet in a damaged condition are standing, may probably be looked for in its incomplete protection against scour.

OSCEOLA SECONDARY NO. 3.

Osceola Secondary No. 3, established near the head of Osceola Chute, and running east and west, was begun May 10. Work on it was pushed as fast as possible, but ere it had been finished, high water, with drift and its attendant scour, caused a break near the bar or eastern end of the dike. As at Secondary No. 1, it was also found necessary here to change the direction of the washed-out section, in order to avoid the deep water resulting from the scour. A third row of piling was also put in, as an additional means of strengthening the dike, thus giving it an average width of about 60 feet. As the water continued rising and the drift kept coming in, a renewal of the scour was observed. With the intention of checking it a 75-foot mat in front of the dike was started. When 209 feet of the same had been built, progress was stopped for a time by the drift, which so held the mat barge, that it was found impossible to make a shift. In the hope that a way for the barge might be cleared by sinking the drift, sections of sub-mat were built on the latter and sunk. Two thousand seven hundred feet of this kind of mat went down successfully, and we were enabled to add another 30 feet to the length of the foot-mat, but this was all. For when, June 6, the attempt was made to sink a second section of drift of about 4,232 square feet of surface, the dike, already weakened by scouring, could not stand the pressure of the sinking mass and gave way. Through the break so formed, 140 feet in length, a large amount of accumulated drift passed off, considerably relieving the pressure on the remaining portion of the dike. Steps were immediately taken to prevent any further scouring in the break. A piece of mat was built above the same, floated down, and about two-thirds of it, or 6,940 square feet, sunk in place. As the current was very swift and the average depth of water in the opening 45 feet, one-third of the mat was carried away before we could get it down.

In the mean time the 239 feet of foot-mat had been sunk and a large amount of grillage foot-mat put in. On account of the high water, no attempt was made for some time to close the gap. Repeated soundings showed that no additional scouring was taking place. [illegible] tipped mat [illegible] feet wide was started in front of [illegible] feet of [illegible] which [illegible] presented [illegible] sketch. [illegible] A 20- [illegible] barely [illegible] necessary [illegible] compara- [illegible] future [illegible] inclined [illegible]

All the remaining [illegible] has been protected by a heavy grillage foot-mat. [illegible] behind the opening [illegible] August 7 a tipped mat 75 feet wide, beginning at the western end [illegible] lodged on drift, was started on the upstream side of the dike. [illegible] skirting the outside edge of the drift, and with [illegible] edge kept on a level with the same, was carried a distance of 472 linear feet. Shoal water then put a stop to the work and the amount finished was sunk successfully. From the foregoing it will be seen that Osceola Secondary No. 3 is well protected now. A grillage foot-mat extends its whole length and is carried high up on the banks. With the exception of the small piece [illegible] all of it is in place and has done good service during the last high water. The effect of the tipped mat can only be determined after the next rise. The center row of piling is now being wattled, [illegible] square feet having been put in to date. From the plotted list of soundings sent in by me, the fill which has gradually taken place in Osceola Chute can be traced. The evil effects of the break have been obliterated, the scoured hole causing the former having filled up well. I think I am justified in classifying Secondary No. 3 with Secondary No. 1, under the head of successful dikes.

OSCEOLA UPPER BAR.

e head of this bar was well protected by a foot-mat 50 feet in width, and by a ot revetment, closely connected with the former. About 800 linear feet of this -graded work were executed, all of which is in good condition to date. That ame cannot be said for some of the other work on the bar is easily explained. A oot mattress was put in the whole length of Osceola Upper Bar and sunk. This at low water. Though the grading and revetting were started immediately in of the mattress, it was impossible to finish them before high water set in. Of linear feet of grading put in, 2,100 were rendered entirely worthless, because the r covered the banks before they could be revetted. The 1,400 feet that were ed with brush and partially rocked also suffered heavily, for the reason that no ection between the high and low-water protection could be secured. The banks ing away between the two has left a gap, as shown in sketch, which it will be sary to fill with a second mat.

OSCEOLA LOWER BAR.

ring the high water in June and July, while it was found impossible to work at dary No. 3, a 100-foot mattress was started on the inside of the lower bar. y drift running necessitated the building of a drift-boom, in shape of a spur from the head of the bar down the chute for a distance of about 100 feet. Under otection 1,020 linear feet of mattress were built and sunk in place. A small section, y 120 feet, near the head of the bar, was put in when the water fell, and remains ighted to date for lack of stone. The bank protection on the inside begun June abandoned June 8, on account of high water, was continued August 13. By ist of the same month a total of 72,422 square feet had been made, of which 49,931 e feet remain unrocked to date. Of the 4,040 linear feet of grading put in last ary on the outside of this, the lower bar, no traces remain, as the graded bank ntirely unprotected when high water came up. This was to be expected. Eight red feet of a 100-foot mattress, which was also started at that time, were ht afloat by the same rise. Drift collected under the mat, and would have ren- l all attempts to sink it futile, even if rock had been on hand for that purpose. s constantly expected, the increased strain on the head-lines, due to the accumu- g drift, caused them to part. Even one of the capstans of the mat barge was out of its fastenings, when the lines snapped, and mat and drift swung down the . Of the new one, 150 feet in width, which was started September 1, 3,583 linear have been completed to date, but only 920 feet of this amount have been sunk; on the same has been stopped for the present, it not being deemed advisable in of former experiences to carry the mattressing too far ahead of the grading and tting. Another precaution has also been taken. Though the contour of the bar been closely followed by the mat in most places, it has been impossible to adapt atter to any sudden changes in the outline of the bank. The small openings thus ed between mat and shore have been covered with separate pieces of grillage firmly wired to the mattress proper. Four thousand four hundred and sixty e feet of this kind of matting have been called for to date, and more will be put the necessity for so doing arises. By this means a thorough connection between high and low-water protection can be obtained, *i. e.*, if the former be put in at the nt stage of water.

ADAPTATION OF PLANT FOR PURPOSES INTENDED.

accordance with your request, I submit, in addition, the following opinion, as to daptation for purposes intended of those articles of plant which I have had oc- n to use.

e 100 foot mat barges, with ways 30 feet long, and a slope of the latter of about sixth, do not fill all the requirements that must be met. Great difficulty in ching the consecutive shifts of a mattress was constantly experienced. This is y due to the slight slope of the ways and partly to the fact that so little space ins between the lower end of the ways and the deck of the mat barge that the r (front) end of the mattress rests on the deck of the barge. In addition the ide butts of the willows do not pay freely over the end kevels, and the want of a an was severely felt. The 175 and 213 foot mat barges, built with projecting more sloping ways, answer their purpose admirably. The latter barge, on which mattress on the outside of Osceola Bar is now building, can, however, only be to advantage in slackwater. In a strong current the handling of it becomes st an impossibility, as I found when this barge was swung across the break in ola Secondary No. 3.

e service barges belonging to the reach answer all requirements.

e new general service barges, 120 by 30, used especially for the transportation ck, are somewhat unwieldy. Even if supplied with capstans, which they are it will always be a matter of some difficulty to handle them with a load of 300 yards of stone.

;. It was not considered necessary to do any work of a permanent char-, as when the dikes are completed the chute will fill up.
mattresses made along the banks of this tow-head, with the exception of 350 the wire-net pattern. This mattress constructed on specially designed ma-es has for its foundation a wire netting made of galvanized iron wire of No. 12 gauge, the heavier wires running longitudinally or up and down e smaller transversely. The distance between the longitudinal wires, which t of the length of the mesh, is 4 feet, while the distance between the others aried. A mesh 4 feet long by 2.5 feet wide has been adopted here. The arried by suitable machinery operated by steam-power from the brush barge attress barge, and deposited upon the netting, where it is received by men upon the mattress and supplied with long hooks, who pack it close together, e time seeing that it breaks joints properly to give it the requisite trans-ness. After brush sufficient for a shift has been thus disposed upon the rush binders are passed over. These are inserted with their butts into and feet through the netting, and then bent over the brush just laid and wired ting. These binders are of course placed at right angles to the brush, and of their length beyond where they are wired will be under the succeeding is makes an excellent mattress, being very flexible in a longitudinal di-iving the necessary transverse stiffness, and is rapidly constructed. One nd eighty linear feet have been made in a day of ten hours when the cur-moderate, and the party not subject to delays in getting brush. Three nd fifty feet of the mattress made here was of the regular pole pattern, brush is alternately woven over and under the poles.
he mattress between Ranges 51 and 52 was begun, it was evident that a f great longitudinal strength to withstand the great strain which would upon it during the operation of sinking would have to be constructed ce the single No. 8 wires were replaced by wire cables made of six of the es well twisted together. These cables were placed 7 feet apart. In other his mattress is similar to the one just described.
h-water bank protection whose lower edge laps over the inner edge of the and which extends to the crest of the bank, consists of a loose brush mat-inuous for its entire length.
ttress is covered with stones, they being placed close together but only one k.
places where, owing to slight settling of the foot-mat, the high and low k protections do not make a good lap, small sections of mat, 100 feet long enough to cover the gap, were constructed upon an ordinary barge placed nd parallel with the bank. One end of these mats rests upon the revet-t when finished the barge is pushed from under the mat, allowing it to fall

[illegible] which were allowed to float away. About 500 linear feet of mat was [illegible] in sinking that new mattress had to be constructed. This is exclu- [illegible] ge resulting from high water, and of which mention has already [illegible]

As the work at this place will ultimately be subjected to a very severe test, the utmost care has been taken to do it properly, and to impart to it that permanency which such work requires in order to answer the purpose of its construction.

Whenever a new section of mattress was begun it was made to overlap the preceding section by at least 25 feet, thus practically making a continuous mattress. The mattress was made to follow the indentation of the bank as close as possible, and where this, owing to the depth and shortness of the pockets, was not practicable, narrow supplementary mattresses were constructed after the principal one had been sunk, these small ones well overlapping the inner edge of the larger ones.

The sketch accompanying this report shows the condition of the work up to date. By referring to it, it will be seen that the length of bank operated upon is 9,625 feet. Of this 7,500 linear feet have been graded by the hydraulic grader and 1,525 feet with shovels, leaving 600 feet still to be graded. Five hundred feet of foot-mat and 2,700 feet of revetment yet remain to be constructed, while of the revetment made a large amount remains to be loaded with stone. That part of foot-mattress at the head of tow-head bounded on each side by Range 50 was constructed prior to December 1, 1882. All the other work has been done since that date.

Wherever the foot-mattresses have been sunk the erosion of the banks has entirely ceased, even at those places where the current strikes the bank directly, and which prior to the construction of mattresses were caving rapidly. Some of the finished work has been exposed to the various stages of the river from a complete submersion to very low water and has stood the test without sustaining the slightest damage.

The dikes, too, though not yet finished, have done admirable work in deepening and widening the channel along the tow-head. Soundings taken in October, when the river was very low, show nowhere less than 12 feet of water, while at most places the depth is much greater. The least depth is at the upper entrance to the channel. None of our steamers have had the slightest difficulty in delivering supplies here, and they have at all times been able to tow the most heavily-loaded barges through.

At the opening of the work last year, nearly all the towing had to be done through the chute on the Arkansas side, and around the foot of the tow-head up as high as they could go.

Attention is respectfully called to the urgent necessity of completing this work before the high-water season sets in. Should the river rise 4 or 5 feet above the present stage, great damage would be done to the unloaded revetment, and a higher rise would seriously damage that part of the bank at the middle of the tow-head not yet protected, and endanger the finished work below.

Appended is a table showing the amount and kind of work done and giving dimensions of the same. No account of the work along dike is taken, as that will appear in the report of the assistant engineer now in charge of the completion of those dikes.

All mattress of a less width than 100 feet is such as has been laid inside of main mattress for the purpose of covering gaps left by the latter. The piece of 150 feet width was laid where the inclination of the bottom was exceptionally steep.

The total length of mattress and revetment made will be found to be respectively [illegible] and [illegible] feet, in excess of the length of bank operated upon. This excess is caused by the reconstruction of damaged work, by the construction of mats to fill gaps between the main one and the shore line or revetment, and by the amount of [illegible].

Work done at Bullerton Tow-head from December 1, 1882, to November 1, 1883.

Class of work.	Dimensions.	Totals.
Foot-mattress made and sunk..	10,[illegible]9 by [illegible] feet, 355 by 150 feet, 2[illegible]8 by 75 feet, 394 by 87 feet.	12,36[illegible] feet = 11,22[illegible] squares.
[illegible] made	8,14[illegible] by 7[illegible] feet	8,14[illegible] feet = 5,69[illegible] squares.
[illegible] loaded	3,5[illegible]1 by 7[illegible] feet, 1,454 by 40 feet	4,9[illegible]5 feet = 3,[illegible]73 squares.
[illegible]	8,9[illegible]0 by 65 feet	8,9[illegible] feet.
[illegible] cords	2[illegible]	2[illegible]3 cords = 97,860 feet.
[illegible] cords	76[illegible]	76[illegible] cords.
[illegible]	2,425 feet	2,425 feet = 1,479 cubic yards

Respectfully submitted.

AUG. J. NOLTY,
United States Assistant Engineer.

[illegible] S. D. KNIGHT,
Corps of Engineers, U. S. A.

I 5.

F F. A. YEAGER, ASSISTANT ENGINEER, UPON OPERATIONS AT OSCEOLA-BULLERTON AND PLUM POINT DIKES.

PLUM POINT DIKE, *November* 1, 1883.

r: I have the honor to submit herewith a report of progress of the work on ullerton and Plum Point Dikes from December 1, 1882, to October 31, 1883.

OSCEOLA-BULLERTON MAIN DIKE.

:ing to this dike, that part starting from Osceola Bar will be called North the part starting at Bullerton Tow-head, South Dike.
ember 1, 1882, about 1,200 feet of North Dike was standing, and on March fleet of eight drivers was put to work, driving until April 13, between which the 18th all drivers were moved to Gold Dust. The dike was then com- but two openings, one of 200 feet, 900 feet from south end of South Dike, 250 feet, about 300 feet farther. From April 18 to June 1, 200 feet of dike he two openings, and 500 feet, about 400 feet from south end of South Dike, it, on account of drift and no foot-mat. June 1 the drivers were again put nd on June 22 the mouth of chute was closed, all but a gap of 250 feet, 0 feet from south end of South Dike, and from June 22 to July 10 drivers on account of having no piles long enough for depth of water. Between d 20, 600 feet between Ranges 49 and 49½, having no foot-mat, scoured out, night of the 21st a large raft of logs lodged on the head of remainder of e, and although this part had been matted, inside and outside, about 200 way. The washing out of this part may be said to have been caused by e quantities of which had accumulated on dike, extending out farther than hus promoting scouring action under the mat at its outer edge.
the night of July 23 the steamer J. S. Woods, with tow of empty barges on dike where Range 49 crosses, catching pile driver No. 17, and pushing h and up the front row of piling, about 150 feet. Shortly after this 454 he same place scoured out, caused by collapsing and imperfect sinking of sters of three piles were then driven about 10 feet apart, and the tops con- h a heavy wire cable. A mat 100 feet wide and 250 feet long was made on of these clusters, but collapsed before sinking was commenced; 250 by 40 ned good and was sunk. The clusters stood erect for three days, when they , and about two weeks later washed out or broke loose. At this time, it was almost impossible to drive to any advantage, on account of rapidity and scarcity of long piles. All dike was now matted, and as the water was boats to run outside of tow-head, a gap of 900 feet was left open for navi- d all force moved down to finish Bullerton Cross-Dike No. 1. Between 10 and 20, 375 feet of dike was added to south end of North Dike, and about 50 th end of South Dike, making North Dike 3,995 feet in length, and South feet, with an opening of 900 feet between them. One thousand three nd fifty feet of North Dike is completely covered with sand, and all the covered but 500 feet at south end. The general condition of dike is given ompanying sketch.

BULLERTON CROSS-DIKE NO. 1.

:e is composed of two parts, one on east side and the other on west side of Chute.
ike runs on a line from 49½ Ark to 52 Bullerton Tow-head, and is 570 feet in East Dike starts midway between 50 and 50½ Bullerton Tow-head, and runs oint 200 feet below 50 Ark. It is 1,200 feet long and makes a curve at 1,130 direction of West Dike. Some difficulty was experienced in the building Dike, as for a time the piling washed out very fast, but after being matted le and outside tip-mat, scouring action ceased, and since that time a fill of taken place, where previous to sinking of mat I reported five piles washed 7 feet of water. The shore at end of dike is protected with 200 by 50 feet rotection above and 150 by 50 feet below dike. Also a foot-mat of same t 100 feet wide. Each dike is all matted inside and as far as practicable

st and West Dikes are in good condition, and a noticeable fill is taking re and below each. From present appearances the chute is slowly filling e channel going on the outside of the tow-head.

PLUM POINT DIKES.

These dikes were started September 20, and as yet little progress has been owing chiefly to scarcity of material. Up to date work has been done only on Dike and Cross-Dikes 1 and 2. The amount of dike completed and incompl given on sketch. Five hundred and fifty-six feet of Main Dike has 100 feet foot and 458 feet has inside or grillage mat between the second and third rows. The age mat is a tip-mat, and was sunk to-day. The foot-mat has not yet been sunk. foot-mat on Main Dike, according to orders, will be sunk flat, and cross-dike have grillage tip-mat and 50 feet tip-mat outside. The shore at head of Main D protected by a revetment 290 feet long and 65 feet wide. The small gap betwee of Main Dike and shore will be closed in a few days and cross-dikes will be fin to shore as soon as possible.

If the material can be had, Main Dike as far as Cross Dike No. 2 and Cross Di and 2 can be protected by the latter part of December.

PLANT.

The small, low, 100-foot mat barge used by me in Bullerton Chute is almost u for making mat in swift water, as it has but one kevel on each end and no cap The new large 157-foot mat boat, with capstan on each end, I am now using that could be desired.

The pile drivers have done very well, but the circular lead drivers are at times awkward to handle, and are the cause of considerable delay. The side lead d are much more convenient and in every way preferable to circular leads.

Very respectfully, your obedient servant,

F. A. YEAG

J. G. D. KNIGHT,
Captain of Engineers, U. S. A.

I 6.

REPORT OF A. P. HATFIELD, ASSISTANT ENGINEER, UPON HYDRAULIC GRADING O TIONS.

ELMOT, ARK., *November* 13, 18

SIR: I have the honor to submit the following as my report of the hydraulic gr performed in Plum Point Reach since December 1, 1882.

On that date I was placed in charge of Grader No. 4. This grader has two Dav pumps, independent action. Plungers 16 inches diameter, driven by two comp engines, the initial or high-pressure cylinders being 18 by 24 inches, the low-pre cylinders 34 by 24 inches. Steam is supplied by a battery of three boilers, 22 feet 44 inches diameter of shell, with five 10-inch flues. Area of grate surface, 56 inches. The vacuum pumps are also of the Davidson style, steam cylinders 10 inches, water cylinders 12 inches diameter. The water supply came from two directly below the pumps; these are 3 feet square, the water passing through strainers of 2,500 ⅝-inch holes. The suction pipe is 14 inches diameter. Th charge is through a boom pipe 60 feet long, having twelve openings fitted with valves; to these the hose is attached. The hose outfit consisted of 4-inch hose sections 50 feet each; two sections 25 feet; two sections 12 feet 2½ inches. R 6-ply hose, four sections, 50 feet, with nozzles 1¼, 1¾, and 2 inches.

December 2, the grader was taken to the head of Bullerton and began work o west side. Here we graded, up to February 9, 9,432 linear feet, and 98,546 y Up to this time the total operating expenses were, for labor, $1,970.12; fuel, $4 subsistence, $548.25; total, $2,958.34. Cost per yard, 3 cents; per linear foot, 31 The grader had a total crew of 17 men, and used about 80 bushels of coal per wo day.

March 26 I was transferred to Grader No. 2. This has pumps of the Deane and, except in being duplex action, they are of the same general dimensions and s power as Grader No. 4.

We again began work on upper Osceola Bar, where we were at work until A the water again rising obliged us to stop. Here we graded 2,900 linear feet. yards. The expense of this period was: Labor, $405; fuel, $83.60; subsistence, $ total, $569.80. Cost per yard, 3.8 cents; per linear foot, 14 cents.

We were laid up on account of high water until July 14, when I was direc take Grader No. 4 and try to wash a channel through the bar forming from ne head of Bullerton toward the head of Yankee Bar. We commenced on the low of the bar, working up-stream with two 1¾-inch nozzles, which were fastened to

vidson and Deane pumps. The advantage seems to be with the Deane for ity of action and their greater solidity acquired by the iron beds and the metal of its parts.

rrangement of the wells under the pumps was found to give trouble by the ucking the sand and muddy water running off the banks, wearing the packing ungers. While laid up during May and June this was changed so that the s now taken from the bow or the point where, as the grader lies to the bank , it is over the deepest water and removed as far as possible from the effect of l from the bank. The wells in the bow seem to act as a settling tank and better water to the boilers and pumps, but they require to be frequently of the mud deposited.

eft pump of Grader No. 4 seemed to have settled out of line, so that during Au- could use but one pump. An examination also showed that part of the valve had become so worn that it was probably the cause of the irregularity of stroke vy pounding for some time noticed in this pump. The rubber valves seem to pidly. Two sets have been used. The worn valves have been refaced in a ut after being so faced have proved to be of very little further use.

rking the grader I have generally used one 1½-inch nozzle with two 1¼ inch. ge nozzle proves to be more effective than two small ones, but the small ones e better grade. There seems to be too much water flowing in one place from e nozzle. When using all, I have had the small nozzles working together near ler, with the large nozzle about 100 feet ahead in a cut by itself. Occasionally m of hard blue clay is found which the smaller nozzles cannot cut, and I have mbined all. The general arrangement of strata has been, on the top a brown m four to twelve feet thick, with underlying strata of sand alternating with t these strata occur in great variety of number and thickness. When the bank ly of clay but little care need be taken for a smooth grade. Where sand oc- method I have used has been to keep the top of the cut a little ahead of the and always keeping enough of the loose soil back of the cut to form a sluice vent the water flowing back over the grade. A gully will be formed at the but, if properly managed, this can be filled by the caving of the bluff, and ce advanced as rapidly as possible. The proper grade should be made at the t; any trimming afterward generally does harm. In some sandy places the y we could prevent gullies was to throw the water from the top of the grade after cutting does not run down the grade, but glances off into the

countered are logs buried in the bank, stumps, the willow espe- willow brush growing thickly with long roots; these form a mat ot penetrate, and must be cut and pulled out. When practicable, standing on the grade; otherwise they are pulled out by the hoist-

the coupling ring. January 6 this occurred, breaking the nozzleman's leg; since then a heavy iron clamp with an eye on one side has been used; the clamp is also riveted to the tube.

For service on the bank I have used one nozzleman and two helpers for the large nozzle, and one nozzleman with one helper for each small nozzle. On the grader we require two engineers, two firemen, a linesman, and helper.

Since April 6, the party has been subsisting on the nearest quarter boat.

To obtain the data necessary to make the reports of the efficiency of the pumps, work performed, &c., the pumps have a "revolution counter" and a scale laid off on the side of the pumps to show the length of the stroke. The steam engineer has on a board placed convenient a blank form (see Form 2), on which he records the exact time of starting and stopping of the pumps, cause of stoppage, and the reading of the revolution counter at time of stopping. The counter is disconnected when the pumps stop, and connected when the pumps are started, after they have made the first few strokes to fill the boom pipe and hose. A record is thus kept of the effective strokes of the pump. The theoretical discharge is computed from the number and length of the strokes. The nozzles also have a pressure gauge at the base where the stream begins to contract, which gauge shows the pressure at this point, and the actual discharge is computed from this pressure according to tables found in "Ellis on Fire Streams." A blank form is fastened up on the grader house, and on it the nozzleman records frequently the pressure of nozzles and pumps at the same time, also the time of observation, length of hose, &c. (see Form No. 4). The steam engineer also makes daily reports (Form 3) of matters pertaining to the working of his engines. From these reports and bank measurements my reports (see Form 1) are compiled.

The efficiency of the water cylinder has varied from 75 to 85 per cent.

The pressures used have generally been about 110 or 115 pounds at the pumps, which gives from 80 to 90 at the nozzles. I at first endeavored to use higher pressure, but the frequent bursting of the 2½-inch hose obliged me to use the low pressure mentioned. This 2½-inch hose was of rubber, 6-ply. The 4-inch hose at first seemed able to endure all the pressure I wished to give, and I had no trouble with it, until after laying up through the high water I tried to use the large hose and nozzles under water washing the bar. Then the hose would not endure more than 80 pounds pump pressure, and this weakness still continued when the hose was used for bank grading. I have cut out the burst places and inserted couplings, but the 4-inch hose on hand is weak and causes delays by its frequent bursting. The 2½-inch rubber hose has mostly been replaced by a cotton rubber-lined hose, Eureka brand. The single 50-foot section furnished me last spring has given good satisfaction, and I believe is still serviceable; but hose of apparently the same kind received since has given much trouble by bursting at very moderate pressure. The first to break gave way at 80 pounds; I had observed the pressure only a moment before it burst. This hose also gives way near the nozzle. The first signs are numerous fine jets issuing all around the hose; these increase in size and number until the hose gives way. The time consumed in replacing couplings, either when the hose has burst or the coupling slipped, has added to the cost of the work. I have endeavored to have sufficient hose on hand so that these repairs could be made at night or at times without interfering with the work, but several times have had to stop and make general repairs. When the cotton hose is not in use, I have kept it on the staging in an inclined and straight position. When in use this hose has no chance to dry, and this may tend to weaken it.

The graders as they are, seem to be very complete for the service, and I have no suggestions to offer as to changes in the general construction. I would only suggest that some arrangement be added that will enable the full power of the pumps to be applied to pumping from the hold in case of accidents or leaks which may endanger the grader.

I append the blank forms used in collecting data for reports.

Very respectfully, yours truly.

S. P. HATFIELD,
United States Assistant Engineer.

Mr. A. J. FRITH,
United States Assistant Engineer in charge Plum Point Reach.

[Form 1.]

TABULAR REPORT.

HYDRAULIC GRADER No. —.

For 10 days ending ——— —, ——.

Area of cross-section.	Cubic yards.	Time in minutes.								Yards per hour.	Bushels coal.	Travel.	Displacements.			
		Working.				Moving.		Delay.					Total for the day.	Per minute.		
		Each nozzle.			Pumps.	Boat.	Nozzles.	Machinery.	Otherwise.					Nozzles used.		
		1¼″	1½″	1¾″										1¼″	1½″	1¾″

ssures.				Nozzles.		Hose.		Discharges.								Efficiency of water cylinder.
	Nozzle.							Each nozzle.						Total.		
								1¼″		1½″		1¾″				
	1¼″	1½″	1¾″	Number.	Size.	Size.	Length.	Theor.	Act.	Theor.	Act.	Theor.	Act.	Theor.	Actual.	

diem.		Cost.		Per cent. composition.				Height of bank.	Profile and strata.	Remarks.
Total.										
Grading.	Other.	Per yard.	Per linear foot.	Brown clay.	Blue clay.	Sand.	Remarks on stumps and obstructions.			

[Form 2.]

STEAM ENGINEER'S REPORT.

Date: ———— —, ——.

Exact time starting.			Exact time stopping.			Reading of counter.	Remarks, cause of del[ay]
1½"	1½"	1½"	1½"	1½"	1½"		

[Form 3.]

STEAM ENGINEER'S DAILY REPORT.

Date: ———— —, ——.

Time of day.	Pressures.			Strokes per minute.		Reading of counter.	Remarks, time of del[ay], cause.
	Steam.	Pump.	Vacuum.	Number.	Length.		

[Form 4.]

NOZZLEMAN'S REPORT.

Date: ———— —, ——.

Time of day.	Pressures.				Length of hose.		Remarks, c[ause] of hose,
	Nozzle.			Pump.			
	1⅛"	1¼"	1½"		4	2½	

I 7.

OF W. H. POWLESS, ASSISTANT ENGINEER, UPON SURVEYS ON THE PLUM POINT REACH.

FULTON, TENN., *November* 5, 1883.

IR: In accordance with your order of September 14, I have the honor to the following report for the eleven months ending October 31, 1883.

and office work.—The following is a statement of the work accomplished by ty:

* * * * * *

ollowing additional maps and tracings have been made:

* * * * * *

rous progress sheets have been prepared, and several drawings made of ery, &c.

ollowing measurements of discharge have been made:

* * * * * *

ollowing miscellaneous field work has been done:

* * * * * *

of the river.—From the hydrograph which accompanies this report it will be at three distinct flood-waves passed down during the eleven months. The attained by their crests, and the dates of their passage at Plum Point, are as :

Date.	Height above low water of 1879.	Height below high water of March 1, 1882.
	Feet.	*Feet.*
March 1, 1883	32.20	0.52
April 18, 1883	28.80	3.92
June 20, 1883	26.75	5.97

irst flood caused a general overflow between Cairo and Memphis; but as it d very rapidly, its effect was less disastrous than that of March 1, 1882. The and third flood-waves only overflowed the banks in a few localities; the latter sed by the Missouri River, and did much damage above Cairo.

ordance with your instructions, the mean stage of the river for the years November 1, 1882, and November 1, 1883, was computed, a planimeter being the purpose. The results obtained were 20.6 and 14.8 feet, respectively. owing table gives the mean stage for the months comprising those years.

Mean stage of river.

Months.	1881 and 1882.	1882 and 1883.
	Feet.	*Feet.*
r	1881, 17.5	1882, 5.6
r	1881, 18.2	1882, 5.2
	1882, 28.2	1883, 9.7
	1882, 31.7	1883, 25.6
	1882, 31.8	1883, 24.4
	1882, 24.1	1883, 26.0
	1882, 25.7	1883, 20.8
	1882, 26.1	1883, 24.0
	1882, 22.0	1883, 19.4
	1882, 11.7	1883, 10.5
r	1882, 8.0	1883, 8.1
	1882, 4.7	1883, 8.4

The following table is also appended.

Number of days on which the stage of the river varies between—	November 1, 1881, to November 1, 1882.	November 1, 1882, to November 1, 1883.
	Days.	*Days.*
0 and 5 feet....	22	75
5 and 10 feet....	45	82
10 and 15 feet....	46	26
15 and 20 feet....	32	61
20 and 25 feet....	73	42
25 and 30 feet....	84	59
30 and 35 feet....	63	20

CHANGES ON THE REACH.

* * * * * * *

The most striking change noted is the great excess of the fills over the scou feature probably due to the February–March flood, the slackening of the current w the water overflowed its banks causing deposits which subsequent floods have a failed to remove.

Ashport Bend.—In the bend above Daniels Point rapid caving occurr du medium and high stages, and an unusually swift current existed. (During the ruary–March flood the surface velocity in this bend, about 300 feet from the ca bank, was 9 feet per second or 6 miles per hour.) The material derived from caving was probably deposited over the bed of the river in Ashport Bend, where current was much more slack. This deposit in turn caused a contraction of secti area from which the river, owing to the curvature of its left bank and the na of its material, sought relief in caving rather than in bed erosion. Approximate ues of the volume of scours and fills in this locality were as follows:

	Cubic
Volume of caving bank in bend above Daniels Point	170,000
Volume of caving bank in Ashport Bend	106,700
Volume of bed erosion in Ashport Bend....................................	86,000
Volume of fill over bed in Ashport Bend	429,200

Assuming that the volume of caving in the Ashport Bend has been carried be the volume deposited in the bed which has been derived above from sources o than the caving bank in the bend above Daniels Point is 152,500,000 cubic feet.

The values of the mean depths, widths, and sectional area at low water are g in a table accompanying this report, and are also represented graphically on a trac The following are the mean values in this part of the river.

Mean changes in Ashport Bend, Nos. 20–27, both inclusive.

Decrease in high-water sectional area ....square feet..	10
Decrease in low-water sectional area ....do....	9
Decrease in low-water mean depth ....feet..	
Increase in low-water width ....do....	

* * * * * * *

Ranges Nos. 27–31.—The changes over this portion of the river consist in a s along the main dike and a fill in the channel. The maximum value of the form 10 feet and its average about 5 feet. The maximum fill, 23 feet, occurs on No. 30

Main river, Nos. 32–38.—An inspection of Nos. 32 and 33 shows that a very he fill has occurred off Elmot Bar, which has been accompanied by marked cavin the Arkansas shore. On No. 33 the area of this fill and caving are nearly equal, on No. 32 the fill is largely in excess. The caving in this locality has formed a point below No. 33, the tendency of which is to throw the water toward the foo Elmot Bar. This effect is particularly noticeable on No. 36.

Elmot Chute.—The changes in this chute are as follows: Over areas behind the dikes a fill has generally resulted; over areas behind the gaps recently closed a s has occurred; on Nos. 30 and 31, at Keys Point, a caving bank and a making have shifted the channel to the south, while lower down along Elmot Bar, from N to 37, similar causes have shifted the channel to the north. Below No. 38 the c has made a new low-water mouth along the outside of Island No. 30, causing heavy scours. Owing to this and to the caving banks before mentioned, the resul

in the high-water sectional area shows an increase. The increase in the area w-water section is not so marked, owing to the bulk of the erosion occurring w-water mark.
ollowing are the values of these changes:

Mean changes in Elmot Chute.

42, excepting Nos. 28 and 31:

ease in sectional area, high water	square feet..	3,340
ease in sectional area, low water	do....	420
ease in mean depth, low water	feet..	1.1

pper mouth of Elmot Chute at the foot of Elmot Bar is about the same as the December–February survey. It filled up completely during the high at cut out again when the river fell.
No. 30.—The closing of this chute at its head, which was commenced in 1881, tinues. It is now entirely cut off at the low stage, and has not been taken unt in computing mean values of low-water areas, &c.
ean changes in its three cross-sections are as follows:

in high-water sectional area	square feet..	2,53.00
in low-water sectional area	do......	710.0
in low-water mean depth	feet..	0.6

Chute.—The changes in this chute have been as follows:

Upper Osceola Chute, Nos. 39½, 40, 40½, 41, 41½, 42, *and* 43.

rease in high-water sectional area	square feet..	4,396.0
rease in low-water sectional area	do......	946.0
rease in low-water mean depth	feet..	1.9

aximum fill 17½ feet, occurs on range 42.

Lower Osceola Chute, Nos. 45–47.

rease in low-water sectional area	square feet..	40

River, Nos. 37–50.—On this portion of the river the most noticeable change is inued caving along Osceola Bar, extending from Nos. 41–47, and tending to channel still further toward the Arkansas shore. The closing of chute No. stages, and the deepening of the lower mouth of Elmot Chute, have caused l shoaling (maximum value, 44 feet on No. 42) of the old channel, and a scour g the Tennessee shore, against which the water from Elmot Chute impinges. ter is there deflected and then scours the old channel at No. 44, and thereby he fill in the locality where the Government fleet formerly lay. It also apst a shoaling of 22 feet has occurred at the Plum Point Landing (No. 45). 8, a fill averaging 16.4 feet has occurred for a distance of 2,400 feet, in front sceola–Bullerton Dike, while a marked scour has taken place in the channel. his dike a fill averaging 10 feet in depth has occurred on No. 48 for a distance et, and on No. 49 a fill averaging 10.6 feet extends to the Arkansas shore.

Main river, No. 50, *to head of Yankee Bar.*

. 50 a scour has occurred on the upper side of Bullerton; shoal water still s along the outside of Bullerton Tow-head off its head, but a channel has out about 1,200 feet from it, giving 10 feet at low water down this passage. o. 50 a fill has generally occurred over Bullerton Bar, except on range 56, scour has taken place, owing to the recession of the bluff sand-bank which right shore of the Tennessee Chute, below No. 55. A marked scour has ocf the outside of Bullerton Tow-head, at No. 52 and 53, and a deepening has en place at its foot. This latter change is not shown on the tracings; it ocetween the surveys of August and October, and amounted to 3 feet.
ee Chute.—The following show the mean changes in Nos. 50, 51, 52, and 53, in te:

	Square feet.
in high-water sectional area	1,212
in low-water sectional area	1,481

head of Yankee Bar.—Below Range 58 the changes are not very marked. Owing water caving, No. 58, which formerly crossed Yankee Bar, now passes above ing still continues above Craighead Point.

Yankee Bar Chute.—No data exists for noting the changes in this locality. Appearances, however, indicate a fill throughout its whole extent.

Changes in Elmot and Island No. 30 chutes between surveys of April, 1882, and September-October, 1883.

The surveys of April, 1882, being made before the dikes were commenced, this comparison gives an idea of the changes caused by them. The caving of the banks at Key's Point and Elmot Bar and the deepening of the chute below No. 38 had begun several years before the dikes were commenced, and their erection has not as yet caused any changes in these localities. The shoaling of the chute of No. 30 at its head is of several years' standing, and still continues.

On a tracing the dikes are shown as they existed about August 1, as the gaps in them which have very lately been closed must have influenced greatly the changes which have occurred. These changes are very similar to those already noted above as occurring between the surveys of December-February, 1882-3, and October, 1883. On No. 31, outside of the dike, a fill is shown, but the former comparison shows that this has since been scoured away.

The mean changes which have occurred in these chutes are as follows:

Increase in high-water sectional area	square feet..	1,273
Decrease in low-water sectional area	do	557
Increase in low-water width	feet..	106
Decrease in low-water mean depth	do ..	0.1

An approximate value of the excess of the volume of scour over that of fill between the high-water sections, from 28 to 42, is 22,426,000 cubic feet.

Gauging observations.—Gauging observations have been made with double floats, run at mid-depth and observed from the end of a base-line several hundred feet long. An ordinary watch was used for observing time. The distance over which the passage of floats was observed was 200 feet.

The computed discharges mentioned in the table of results given below (Appendix) have been computed from the equation of the Fulton discharge curve given in my report of July 11, 1881, to the Commission. The observed values of the discharge of the river at Bullerton Tow-head on September 5 and October 26 differ from those computed by 3½ and 1 per cent., respectively.

It will be seen that the discharge in Lower Osceola Chute ceases at a stage of about 4 feet; at a stage of 25 feet it passes about 7 per cent. of the volume of the river. The observations taken in Elmot Chute show that in June the upper mouth discharged about one-half more than the lower mouth, but that in October these discharges were about equal. The discharge of Chute 30 ceases at about a 6-foot stage.

The ratio of the discharge of Bullerton Chute to the entire discharge of the river varies inversely as the stage. On September 15 (stage 4.9 feet) its value was 0.62; on October 26 (stage 5.4 feet) this was reduced to 0.50, owing to a scouring, both in the Tennessee and middle channels.

SLOPE OBSERVATIONS.

A table accompanying this report gives a comparison of the profiles of the river on March 1, 1882, on which date it reached the highest level on record, and on October 12, 1883, when the stage at Elmot was 3 feet above low water of 1879. It will be seen that the value of the fall from Ashport to Fulton is 1.36 feet greater at the low than at the high stage. This difference is a maximum at Petty's Landing, the fall between that point and Ashport being 3.28 feet greater at the low stage.

The following values of the fall through Bullerton Chute from Driver's to Petty's Landings, are given:

Date.	Above low water at Driver's Landing.	Fall.
	Feet.	Feet.
March 1, 1882	33.?	0.6?
October 12, 1883	2.1	2.5?
November —, 1879	0.2	3.2?

From the tracing showing the two profiles, it is seen that the excessively high slope in the vicinity of Bullerton Tow-head is accompanied by a low value of the curve of mean depth; also, that a marked scour has occurred in the locality where at the high-water of March 1, 1882, a very heavy slope was found.

During the low-water surveys of August-September, 1883, and October, 1883, great variations were found in the level of the water at the opposite extremities of the cross-sections in the vicinity of Bullerton Tow-head, caused doubtless by a shoal at

end of the Tennessee Chute, acting as as a dam and forcing back the water. ber 22 the following differences in elevation were found:

	Feet.
of No. 50 Tennessee above No. 50 Arkansas	0.62
of No. 51 Tennessee above No. 51 Arkansas	1.33
of No. 53 Tennessee above No. 53 Arkansas	1.62
of No. 54 Tennessee above No. 54 Arkansas	1.73
of No. 58 Tennessee above No. 58 Arkansas	1.78

ion is now occurring at this shoal in the chute, the effect of which will be he above differences and increase the discharge.

CAVING BANKS.

Bend.—The length of the caving bank in this bend is about 14,000 feet, from No. 21 to 26, and the greatest annual rate of caving is at present 540 caving since the fall of 1879 has amounted to about 700 feet. As far as caving here occurs wholly at medium and high stages.

letcher's.—Caving here extends from the mouth of Mill Bayou to the false w No. 33, a distance of 8,000 feet; of late, however, but little caving has above No. 32. The maximum caving now occurs at No. 33, where the annual feet.

f Elmot Bar.—Below No. 34 the caving which was in progress in 1879 still ontinues, and to it is due the erosion of the lower mouth of Elmot Chute and e of Chute No. 30 at its head. The length of the caving is about 5,000 feet, resent maximum rate is 360 feet per year.

of Osceola Bar.—The caving in this locality has been in progress since 1879, h date the head has receded down-stream 3,000 feet, and the cut now known ldle entrance formed. The caving since 1879 has been 1,600 feet at No. 41, t No. 44. The maximum caving of late has been at No. 44, where the bank ed 250 feet in ten months. At present no caving is occurring in the locality, having been revetted.

ns Souci.—Caving still continues in this locality and is most marked at the owing to the swift current in Bullerton Chute. The length of the caving bout 3,700 feet, and its present maximum rate 270 feet per annum.

above Craighead Point.—This caving occurs almost entirely at medium and es. Its length is about 15,000 feet extending from No. 56 to No. 68. The rate is about 260 feet per year.

Yankee Bar.—At high stages a very swift current was thrown against the ankee Bar, due probably to heavy fills in Yankee Bar Chute. The bank posed of sand has receded very rapidly, the amount of recession being 1,200 January to October, 1883.

igh-water caving has occurred at Keys Point, left bank of Chute No. 30, and shore below Plum Point.

* * * * * * *

SUMMARY OF CHANGES ON THE REACH.

lowing table exhibits the mean values of cross-section areas, &c., from oint to Fort Pillow. In all computations relating to low-water dimensions, ring chutes in which no current exists at low water have been disregarded.

Ashport, Osceola, No. 30, and Yankee Bar.

Mean values No. 17 to 71.

ese volumes have been measured with a planimeter from curves shown on tracing.)

in high-water sectional area	square feet..	4,438
in low-water sectional area	do....	4,728
in low-water mean depth	feet..	0.9
in low-water width	do....	109
w-water sections December, 1882, February, 1883	square feet..	49,520
w-water sections October, 1883	do....	44,792
er mean depth December, 1882, February, 1883	feet..	15.4
er mean depth October, 1883	do....	14.5
er width December, 1882, February, 1883	do....	3,308
er width October, 1883	do....	3,199

ue of the decrease in high-water sectional area would be probably materially if the fills in Ashport and Yankee Bar Chutes had been ascertained. This however, has not effected the values for the low-water sections.

The following is a summary of the volumes of fills and scours over the rea between the surveys of December, 1882, February, 1883, and October, 1883.

	Feet.
Volume of fill below ordinary high-water mark	726,500,
Volume of fill below low-water mark	655,000,
Volume of fill above low-water mark	70,700,
Volume of scour below ordinary high-water mark	257,900,
Volume of scour below low-water mark	142,500,
Volume of scour above low-water mark	115,400,

* * * * * * *

My assistants, Messrs. Phillips, Maurer, and Clark have rendered valuable and cient service.

Respectfully submitted.

W. H. Powless,
Assistant Engine

J. G. D. Knight,
Captain of Engineers, U. S. A.

Results of gauging observations.

Locality.	Date.	Elmot gauge.	Area at cross sections.	Mean depth.	Mean velocity.	Maximum mid depth velocity.	Observed discharge.	Ratio of observed discharge
	1883.	*Feet.*	*Sq. feet.*	*Feet.*	*Ft. per sec.*	*Ft. per sec.*	*Cu. ft. per sec.*	
Elmot Chute at Range 33	June 27	26.60	75,781.5	21.9	4.70	5.90	357,051.4	
	July 18	17.00	49,150.0	16.1	4.00	4.55	196,261.0	
	Oct. 11	2.69	......	......	......	......	22,892.0	
Elmot Chute at foot of Elmot Bar	June 25	26.50	......	......	......	......	215,381.4	
	July 18	17.00	......	......	......	......	97,675.0	
	Sept. 20	2.60	2,973.0	6.4	3.71	4.09	11,028.0	
	Oct. 11	2.69	3,570.0	6.6	3.20	3.70	11,592.0	
Elmot Chute, lower mouth, at Range 29	June 25	26.50	28,154.1	28.4	5.0	5.26	141,670.0	
	July 19	17.55	26,531.1	22.3	4.8	5.55	98,586.0	
	Sept. 20	1.95	5,160.0	6.1	1.76	2.17	8,984.0	
	Oct. 11	2.70	5,450.0	6.5	2.09	2.70	11,300.0	
Small chute opposite tow-head on Range 33	June 26	26.60	9,136.0	15.8	3.80	4.20	35,077.0	
	July 18	17.00	3,761.0	7.2	3.80	5.71	14,344.0	
	Sept. 20	1.95	......	......	......	......	0	....
	Oct. 11	2.70	......	......	......	......	0	....
Chute No. 30	June 26	26.60	......	......	......	......	159,824.7	
	July 18	17.00	......	......	......	......	57,850.2	
	Sept. 20	1.95	......	......	......	......	0	....
	Oct. 11	2.70	......	......	......	......	0	....
Osceola Chute at Range 41	July 5	25.80	21,449.0	17.3	1.2	1.8	26,545.2	
Osceola Chute, Range 42, Arkansas shore	July 5	25.80	8,562.0	14.9	1.57	2.00	13,552.6	
Osceola Chute, Range 45	May 10	23.30	16,356.8	21.6	3.60	4.20	59,074.5	
	July 5	25.80	16,687.0	20.2	4.00	4.60	65,671.8	
	July 17	16.60	9,000.0	13.2	3.12	3.60	28,148.0	
Osceola Chute, Range 48	Sept. 5	4.95	3,364.0	8.2	0.36	0.45	1,211.0	
Bullerton Chute at Range 53	May 10	23.30	42,180.5	40.9	4.60	5.35	194,774.4	
	July 17	16.60	35,924.0	37.2	5.02	5.80	182,235.0	
	Sept. 5	4.95	24,688.0	25.5	5.10	7.00	126,431.0	
	Oct. 26	5.35	24,050.0	23.4	4.48	5.27	107,711.0	
Middle Channel, Range 53	Sept. 5	4.95	18,700.0	9.2	2.80	3.71	52,238.0	
	Oct. 26	5.35	18,600.0	8.6	3.54	4.32	65,875.0	
Tennessee Chute, Range 53	Sept. 5	4.95	10,400.0	7.7	2.50	3.13	25,502.0	
	Oct. 26	5.35	12,050.0	8.5	3.34	4.50	40,255.0	

Discharge of entire river at Range 53.

	Elmot gauge.	Above low water at Fulton.	Sectional area.	Width.	Mean depth.	Mean velocity.	Observed discharge.	Computed discharge.	Difference.
	Feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
3.	4.95	6.21	53,788	4,345	12.3	3.7	204,100.0	211,700	7,600
3.	5.35	6.24	54,720	4,613	11.8	3.8	213,841.0	211,724	2,117

mber 5 the river was falling. On October 26 the river was stationary.

APPENDIX X.

OF MAJOR A. M. MILLER, CORPS OF ENGINEERS, UPON OPERATIONS IN THE SECOND DISTRICT, MISSISSIPPI RIVER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., November 12, 1883.

EL: In compliance with your letter dated September 6, 1883, I have the submit the following report of work done since December 1, 1882, in the istrict, under the supervision of the Mississippi River Commission.

MEMPHIS REACH AND HARBOR.

Bank protection.

ember, 1882, a project was submitted for work on the Memphis Reach, from land No. 40 to Scanlan's Landing, and the revetment of the bank in Hoped on the west bank, and from Frame's Chute to mouth of Wolf River on the t, was approved by the Commission, an allotment of $300,000 having been this purpose, and at a subsequent meeting of the Commission, on my urgent tation, an additional allotment of $25,000 was made for the purpose of revetsecuring the bank on the Memphis front, from the freight elevator to mouth River, where caving seriously threatened great damage and the probable struction of very valuable mills, the cotton compress, and freight elevators.

MEMPHIS FRONT, BELOW WOLF RIVER.

ork of sinking mattresses was nearly completed on December 1, 1882; since five mattresses were sunk, three in the vicinity of the cotton compress, and ront of the city levee, as shown on map. The upper bank was graded by m the elevator to cotton compress and revetted with willows and broken stone. ion to the revetment of the bank it was necessary to build wooden culverts he city drainage to low water, in order to prevent its cutting the bank into nd thus causing fresh caving.

ount of work completed here was as follows: Five mattresses 60 by 120 feet = r feet; 13,700 cubic yards bank excavation; 362 feet wooden culverts 2 by ,273 square yards of upper bank revetment.

ork has apparently accomplished the object for which it was constructed, he prevention of further bank caving. It has stood well the high water of l quite a growth of willows has made its appearance on the upper bank revetome repairs may be necessary from time to time to keep the culverts in order.

REVETMENT OF HOPEFIELD BEND.

ork consisted in sinking deep-water mattresses, building upper bank protecl the grading of bank above low water. The object of the work is to hold

the river in its present channel, thus preventing a possible cut-off, which would leave the city of Memphis away from the river.

The project contemplated the revetment of the bank from Mound City Landing above, for a distance of two miles, to a point in the vicinity of Hopefield.

Active operations were begun in December, 1882, by the employment of hydraulic grader No. 2, in grading the bank and mattress sinking, which was continued until February 10, 1883, when high water put a stop to the work. Owing to the condition of the river during the sinking of mattress work, rapidly rising water, much difficulty was experienced from drift and a strong current, it was therefore not considered safe to construct continuous mats. The mattresses were therefore sunk in lengths varying from 250 to 300 feet, all having a width of 140 feet.

On February 10, 1883, high water caused a suspension of the work, at which time 1,127 linear feet of mattress 140 feet wide had been placed in position.

Work was resumed in August, 1883, and is still in progress.

The total amount of work done since December 1, 1882, to October 31, 1883, has been as follows: 6,956 linear feet of mattress 140 feet wide made and sunk; 7,1[illegible] linear feet of mattress 140 feet wide made; 67,242 cubic yards of bank-grading; 6,662.5 cords of willows cut and delivered; 415 cords of poles cut and delivered; 4,922.25 square yards of upper-bank protection made.

In addition, snagging, bank clearing, and repairs were carried on, for details of which reference is made to the report of Mr. W. M. Rees, assistant engineer (marked B), forwarded herewith, whose diligence and tact in immediate charge of the work has been of great value.

The portion of the bank revetment 1,127 linear feet, built December, 1882, to February, 1883, and which has experienced the effects of the high water of 1883, when the water was 5 feet over the banks at the point revetted, has shown good stability. After the water fell a small cave occurred, owing to a want of continuity of the mattresses, which was rectified by placing a mattress over the vacant spot. The upper end or head of the mattress work will require some additional work to secure it, but in its present condition is secure from serious damage. The effect of the next high water upon this work is looked forward to with great interest, as it will probably decide many points in this method of protection. It does not apper to be advisable to undertake this kind of work until the water has nearly if not quite reached its lowest stage, although this depends somewhat on the depth of water at the bank to be revetted. At high water it has been found very difficult to place the mats in proper position, as the tendency is to slide or run up against the bank, thus resulting in upper bank protection, when it is essential that the lower bank should first be held. The principal cause of delay in the work has been difficulty in procuring willows. During low water, when it is absolutely essential to push the work as rapidly as possible, the very worst conditions obtain in reference to procuring willows; that is they must be hauled quite a distance to get them on the barges. This is the principal item in their cost. The practice on this reach has been to build wooden tramways and cars and haul them by mules. It is not possible to obtain willows at high water and keep them on hand for use, as they must be fresh, or are so brittle as to be useless for weaving. Delay from lack of stone has not been felt very seriously on this work as the amount required has been comparatively small; on one occasion recourse was had to sacks filled with buckshot clay to sink a mattress, and the work seems to have held well; 4,[illegible] gunny sacks were used at a cost, and loaded on barges, filled, of about $[illegible]; their weight was equal to about 214 cubic yards of stone.

Labor has been plentiful, but difficult to keep employed on account of the unhealthy climate. White labor has been employed with the exception of one willow party, which was composed of negroes with white overseers. They gave better satisfaction cutting willows than white labor, but were more difficult to keep, as when a week's wages were due them they would quite generally leave and lay idle till their wages were spent.

The report of Assistant Engineer Joseph Burney (Appendix K 1) showing all the work done on Memphis Harbor is transmitted herewith.

REPAIR OF LEVEES, YAZOO FRONT.

The Board of Engineers convened by Special Orders No. [illegible], Headquarters Corps of Engineers, Washington, D. C., August [illegible], 1882, for the transaction of certain business connected with the repair and building of levees on the Mississippi River, opened bids for the construction and repair of levees September 25, 1882, and a further letting was made on October 16, 1882. The following are the abstracts of bids for repairs of levees in the second district of the Mississippi River Improvement.

Abstract of bids opened September 25, 1882.

	Names of bidders.	Locality of levee.	Price per cubic yard.	Price of felling timber.	Remarks.
1	R. G. Huston, Cincinnati, Ohio, John B. Neely, Chattanooga, Tenn.	Parker's Enlargement and breaks.	$0.37		
2	J. W. Eldridge, Lake Charles Landing, Miss.	Lake Charles break	30½ 25½	$80 per acre.	Excavation. Embankment.
3	McGavock & Tate, Memphis, Tenn.	Parker's Enlargement and breaks.	32	Cost and 10 per cent.	
4	Wirt Adams, president Mississippi Contract and Improvement Company, Jackson, Miss.	Parker's Enlargement and breaks. Lake Charles break	23 22	(*)	

* Heavy clearing, $48 per acre; light clearing, $36 per acre.

NOTE.—Contracts were awarded to McGavock and Tate for Parker's Enlargement and breaks, and J. W. Eldridge for Lake Charles break, Wirt Adams having declined on account of decision refusing employment of convict labor.

Abstract of bids opened October 16, 1882.

	Names of bidders.	Locality of levee.	Price per cubic yard.	Price of felling timber per acre.	Remarks.
1	Patrick F. Lamb, Bolivar County, Mississippi.	Bland's Bayou to Garland's.	$0 25½ 28	$75 00 75 00	Embankment. Excavation.
2	W. M. Forrest and J. T. Stanton, Memphis, Tenn.	Garth's break to Jefferson's.	22½ 27½ 24½	50 00 50 00 50 00	Jefferson break. Beard break. McCloud break.
3	Arnold & Co., Memphis, Tenn.	......do	23½	75 00	
4	McGavock & Tate, Colorado.	Bland's Bayou to Garland's Garth's break to Jefferson's.	24½ 28	75 00 40 00	
5	Andrew Bodkin, Memphis, Tenn.	Bland's Bayou to Garland's. Garth's break to Jefferson's.	28 25	40 00 40 00	
6	F. Gilleely and John Clancy, Memphis, Tenn.	Bland's Bayou to Garland's. Garth's break to Jefferson's.	25 24½	40 00 45 00	
7	Timothy Sullivan, Doniphan, Mo.	......do	22	75 00	

NOTE.—Contracts were awarded to Timothy Sullivan for levee from Garth's break to Jefferson's, and Arnold & Co. for levee from Bland's Bayou to Garland's, their bids being the lowest.

Work was pushed on these levee repairs, and the following work was completed and paid for:

Locality of levee.	Amount of work done.			Cost.
	Embankment.	Excavation.	Clearing.	
	Cubic yards.	*Cubic yards.*	*Acres.*	
Parker's enlargement	89,322	....	....	$28,583 04
Lake Charles break	88,868	1,061	14.30	11,179 30
Bland's Bayou to Garland	44,800	....	22.83	12,800 25
Garth's break to Jefferson's	86,552	....	45.23	22,554 11
Total	259,542	1,061	82.36	75,116 70

All the contractors completed their work before high water, and final payments were made. Since the completion of the work the levee has broken again at the McCloud break, and should be repaired.

SURVEYS.

A survey of the Memphis Reach was completed February 21, 1883, by Ass[illegible] Engineer F. S. [illegible], whose report (Appendix K 3) is herewith submitted.

A survey of the [illegible] Reach from Commerce Cut-off to Friar's Point wa[illegible] pleted January [illegible], 188[illegible], by Assistant Engineer F. A. Fisher, whose report is her[illegible] submitted (Appendix B 4).

A survey, reconnaissance, and estimate for repairs of levees in the second d[illegible] was completed by Assistant Engineer Richard Klemm, whose report is sub[illegible] (Appendix K 5).

A low-water survey of the Memphis Reach was made in September, 1883, by [illegible] S. [illegible], draughtsman, on which sheet is plotted the shore lines and pres[illegible] dition of the work, and which is submitted with this report.

Tables showing detailed statements of expenditure under each allotment from [illegible] priation for Mississippi River in this district, also table showing amount of [illegible] purchased for the Memphis Reach, with cost of same, are transmitted herewit[illegible]

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engi[illegible]

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, United States Army,
President Mississippi River Commission.

List of floating property bought for use at Memphis Reach and Harbor, with cost [illegible]

Description.	No.	First cost.	Total cost.	Remarks.
[illegible]	[illegible]	[illegible]	[illegible]	
Do	3	1,[illegible]	3,[illegible]	
Total	[illegible]		[illegible]	
[illegible]	2	[illegible]	[illegible]	
[illegible]	4	1,[illegible]	[illegible]	
Total	[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
Do	[illegible]	[illegible]	[illegible]	
Do	[illegible]	[illegible]	[illegible]	
Do	[illegible]	[illegible]	[illegible]	
Total	[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	$[illegible] paid prior to Decemb[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	
Total			[illegible]	

[illegible] cost of tools.

A. M. MILLER.
Major, Corps of Engi[illegible]

[illegible] STATEMENT OF EXPENDITURES FOR MEMPHIS REACH AND HAR[illegible]

[illegible] .... $[illegible]

[illegible] Amount expended for—

Labor	60[illegible]
[illegible]	[illegible]
Supplies	2[illegible]
[illegible]	1[illegible]
[illegible]	5[illegible]
[illegible]	5[illegible]
[illegible]	1[illegible]
[illegible]	

ber 1, 1883. Amount expended for—	
Freight	$168 85
Traveling expenses	222 83
Office rent	181 00
Fuel	497 80
Telegrams	11 63
Subsistence	16,181 93
Hire of plant	3,198 91
Total	105,890 80

A. M. MILLER,
Major, Corps of Engineers.

D STATEMENT OF EXPENDITURES FOR CONSTRUCTION AND REPAIR OF LEVEES, YAZOO FRONT.

1, 1882. Allotment	$80,950 00
r 1, 1883. Amount expended for—	
Earthwork	75,116 70
Labor	1,499 33
Material	138 00
Supplies	3 30
Outfit	8 75
Assistant engineers	1,600 00
Clerk	175 00
Inspector	600 00
Stationery	8 25
Traveling expenses	267 95
Office rent and quarters	108 50
Telegrams	50 41
Subsistence	36 00
Advertising and printing	220 06
Total	79,832 25

A. M. MILLER,
Major, Corps of Engineers.

ED STATEMENT OF EXPENDITURES FOR SURVEY OF THE HELENA REACH.

, 1882. Allotment	$8,000 00
r 1, 1883. Amount expended for—	
Labor	$3,635 66
Material	41 08
Supplies	58 66
Repairs	6 00
Outfit	607 65
Assistant engineer	1,205 00
Clerk	175 00
Draughtsman	750 00
Stationery	18 85
Freight	29 65
Office rent and quarters	193 00
Subsistence	562 74
Hire of plant	228 00
Total	7,511 29

A. M. MILLER,
Major, Corps of Engineers.

[illegible] EXPENDITURES FOR SURVEY OF SAINT FRANCIS [illegible]

[illegible]		$4,000 [illegible]
[illegible] amount expended for—		
	Labor	$670 [illegible]
	Supplies	61 [illegible]
	Guns [illegible]	500 [illegible]
	Assistant engineer	880 [illegible]
	Clerk	300 [illegible]
	Stationery	19 [illegible]
	Freight	93 [illegible]
	Traveling expenses	106 [illegible]
	Office rent	66 [illegible]
	Subsistence	305 [illegible]
	Hire of plant	120 [illegible]
	Total	$3,212 [illegible]

A. M. MILLER,
Major, Corps of Engineers.

K 1.

[illegible] ASSISTANT ENGINEER, ON OPERATIONS FOR IMPROVI[NG] THE HARBOR OF MEMPHIS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 30, 188[3].

[illegible] to submit my annual report of operations for improvin[g] [illegible] for the year ending June 30, 1883. I was instructed by yo[u] [illegible] of the work in October, 1882. An examination of the mattres[s] [illegible] was made by an experienced diver, and the mattress work wa[s] [illegible] from the mouth of Wolf River to the foot of Jeffers[on] [illegible] of portions of the front near the cotton-shed, Panola [illegible] Brown & Jones' coal-yard. Considerable difficulty had been foun[d] [illegible] the bank, on account of the numerous springs and public an[d] [illegible] the bank continually wet and very susceptible to wash awa[y] [illegible]

[illegible] that this portion of the bank should [illegible] the upper bank, from Wolf River to [illegible] where it could be done without injury to [illegible] drained, the drains being car[ried] [illegible] It was estimated that this work would cost $25,000. [illegible] the tug Tilda was chartered, the [illegible] party sent about [illegible] miles up the river to obtain [illegible] Mattress-ways and workmen's quarters were [illegible] and on October 2[illegible] the first mattress was [illegible] Two mats were sunk at this [illegible] were sunk from Brown & [illegible] and, by request of the city authorities, two were [illegible] Each of the mats sunk was 120 by 60 by 2 feet.

[illegible] that it is much better to reduce the thickness of [illegible] length and breadth; but on this portion of the [illegible] requires the taking possession of a large por[tion] [illegible] for some time, thus preventing the steamboats [illegible] We are generally at work during the busy season, [illegible] us to keep them from the bank, nor will the [illegible] We are compelled to construct our mats some [illegible] down to their position, and sink them. This does [illegible] the steamboats, but it is a very great inconvenience and [illegible] the bank protected is not done in such a substantial man[ner] [illegible] constructed in long lengths in the location where they [illegible]

[illegible] all sunk, work was commenced grading the bank; th[e] [illegible] with the steam hydraulic grader; but, in consequen[ce] [illegible] and other floating property using the bank and th[e] [illegible] would have been very inconvenient and attende[d] [illegible]

culty; so you directed the work should be done by laborers with pick and This is very expensive, as the earth has to be handled so often to get it into . Fortunately, the river commenced rising and we just kept our work above did not require so much labor as if the water had been at a low stage.

rading the bank we connected all the public and private drains and carried to low water by means of wooden culverts. We then laid wire upon the ank, 6 feet apart along the river bank, and 6 feet apart up the bank; upon we placed willow brush 6 inches thick, and then, on top of brush, we placed e as below, and secured same to the lower line of wire by connecting wires, the brush, so that along the upper bank it formed one large mattress.

ork was done from the mouth of Wolf River to the elevator, with the excep- portion of the bank in navy-yard, 242 by 32 feet, and a portion, 200 by 30 ront of Brown & Jones' coal-yard. After the willows were secured to the y were well ballasted with stone, sand-bags and earthwork. This com- e work in a substantial manner, with the exception of the work noted and e amount estimated.

ions were suspended February, 1883, and the plant and outfit turned over to field Bend works.

the time we were at work we had very favorable weather and the river was working stage; but we had considerable trouble to contend with, for want cient number of flat-boats, and considerable delay was experienced for want

iately after the suspension of operations the river rose and covered the whole rk, the gauge reading 34.75. Shortly afterwards the water fell to 18.20, when nation of the bank was made and the work was all found to be in good condi- the slighest sign of a break or crack in the bank appearing.

SUMMARY OF WORK DONE DURING SEASON.

attresses sunk, 120 by 60 by 2 feet.
uare yards of willow brush shore protection.
ibic yards of excavation on bank.
et of wooden culverts, 2 by 2 feet, built.

AMOUNT OF MATERIAL EXPENDED.

ds of willow brush.
ds of cottonwood poles.
k pins, 4 feet long by 1 inch diameter.
k pins, 1 foot long by ½ inch diameter.
nch carriage bolts.
unds wire.
unds rope.
bic yards stone.
d-bags.
bic yards cypress bark.
t of cypress lumber.
t of 6-inch stone pipe.

ave the honor to remain, very respectfully,

JOSEPH BURNEY,
Assistant Engineer.

. M. MILLER,
rps of Engineers, U. S. A.

K 2.

OF W. M. REES, ASSISTANT ENGINEER, UPON IMPROVEMENT OF MISSISSIPPI RIVER AT HOPEFIELD BEND.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., November 1, 1883.

: In accordance with your verbal instructions, I have the honor to submit a operations for the improvement of the Mississippi River at Hopefield Bend, Reach, from December 1, 1882, to October 31, 1883.

ject of this work is to prevent the caving of the bank, now rapidly taking d which threatens injury to the harbor of Memphis.

parison of the survey of September, 1883, with that of December, 1877, shows bank in the middle of the bend has receded 1,500 feet. From August, 1882, nber, 1883, the caving was 300 feet in the middle of the bend, and near the above Hopefield, it was 450 feet. The distance across the neck of land to below is now about 13,000 feet. To arrest this caving the project is to revet with brush mattresses, these mattresses to cover the bank from the foot

DETAILED STATEMEN[illegible] in place by stone evenly distri[illegible]

August 2, 1882. Allo[illegible] parts:
[illegible] bank below the water surface c[illegible]

November 1, 1883. A[illegible] water surface, called shore pro[illegible]
[illegible] water surface to a suitable slope

CONSTRUCTION.

MATTRESSES.

[illegible] 150 feet long by 30 feet wide, [illegible]
[illegible] apart, these skids having an incli[illegible]

[illegible] wattled kind, of brush and poles,
[illegible] Louis, Mo., and at Plum Point, havi[illegible]
[illegible] of diameters not less than 3 inc[illegible]
[illegible] larger, with brush not less than [illegible]

[illegible] with spikes and wire, one pole bei[illegible]
[illegible] or weavers, the brush was wov[illegible]
[illegible] mattresses were to be sunk in deep wate[illegible]
[illegible] other poles, called binders, were pl[illegible]
[illegible] and spliced together. These strengt[illegible]
[illegible] the stone from rolling off when sunk

REPORT OF JOSEPH [illegible] to strengthen the mattress transver[illegible]
[illegible] over the top longitudinals, and wire[illegible]
[illegible] They were spaced from 8 [illegible]

[illegible] was held to a mooring barge by ten
[illegible] inches in diameter were securely fasten[illegible]

MAJOR: I have th[illegible] and led to "dead-men" or trees [illegible]
Memphis River Fron[illegible] barge, which was also secured by tw[illegible]
to take local charge [illegible]
work under water w[illegible] placed along the outer edge of the [illegible]
found in a fair cond[illegible] this, on and over the mattress, and [illegible]
Street, with the exc[illegible] half of the stone used on the mattress w[illegible]
mill, and Messrs. Br[illegible] mooring barge was then thrown on t[illegible]
with this portion of [illegible] produced on the small lines attach[illegible]
private drains keep[illegible] the mattress allowed slowly to sink;
by the steamboat w[illegible] the bottom, then a rock barge was sw[illegible]

In submitting a pr[illegible] held on the mooring barge and on the sh[illegible]
be repaired by matt[illegible] taken to distribute the stone evenl[illegible]
the elevator, be gra[illegible] party is as follows: one sub-overseer in
the property on the [illegible] of the three divisions of work, viz., at [illegible]
ried out to extreme [illegible] barge. Each gang consists of one pate[illegible]
October 18, 1882, act[illegible] men, and three brush men; fourteen in a
quarter-boat fitted u[illegible] barge of brush which is lashed alongside of a[illegible]
cottonwood poles a[illegible] brush to the platform men, who place it in
constructed near the [illegible] push it down into place, where it is firml[illegible]
sunk in front of the [illegible] any openings left in the mattress after w[illegible]
location; three in fr[illegible] the mattress to put on binders and cross po[illegible]
Jones' coal-yard to [illegible] usual force, including everybody, being 52 m[illegible]
sunk in front of Cou[illegible]

Experience in the [illegible] SHORE BANK REVETMENT.
mattress and greatly [illegible]
river front this cann[illegible] After the bank was graded to the prope[illegible]
tion of the river fron[illegible] in the ground, about 8 feet apart longitudin[illegible]
from using the bank [illegible] the bank. A No. 8 wire was then placed
and steamboat-owne[illegible] distance apart being 8 feet. Around this
city authorities give [illegible] and twisted around the stakes so that t[illegible]
distance up the river, [illegible] in position; this was to be used to tie
not interfere much w[illegible] holding the brush in place.
expense to the work, [illegible] on the bank transversely, the butts up th[illegible]
not as if the matress[illegible] water mattress." On top of this a longi[illegible]
are to be sunk. [illegible] No. 8 wire was stretched transversely, at

After the mattress[illegible] water mattress" and also to the bottom wire
work was intended to [illegible] was then well covered with stone. Whene[illegible]
of the number of sto[illegible] joined to the upper bank revetment a fo[illegible]
number of buildings [illegible] was constructed on a small screen bar[illegible]
[illegible] already described.

GRADING.

o revet the bank above the low-water line it was necessary to grade it to ope for holding the brush and stone. During the first part of the work, ber 21, 1882, to January 31, 1883, I used for this purpose hydraulic grader Mississippi River Commission. This was loaned us by Capt. J. G. D. Plum Point, and was returned to him shortly after the high water closed Before again resuming work, August 6, 1883, we obtained a small pump Capt. W. L. Marshall, of Vicksburg, Miss., and with the latter, work is lone. Both will be described.

grader No. 2 consists of a duplex compound condensing plunger pump Dean Pump Company of Holyoke, Mass. The dimensions are as follows: low-pressure cylinder, 36 inches; of high-pressure cylinders, 18 inches; plungers, 16 inches; length of stroke, 24 inches. The stroke is adjustable practice was kept at about 23 inches. The piston speed averaged 61½ feet giving a theoretical discharge of 1,280 gallons of water per minute. This her with three steel boilers of 40 horse-power each, was placed on a barge 6 feet, which contains sleeping quarters for 30 men. Attached to the de- of the pump is a boom 65 feet long, made of lap-welded wrought-iron d with cast-iron connections, and having openings at various points to can be attached. This boom, with a double stage, overhangs one end of and can be raised or lowered by a hoisting engine on deck. When in work the boat was held nearly at right angles to the bank, with the g on the bank. The grader had not been run before we received it, and, ew machinery of large size, some time was lost in limbering it up so as to hly. Delay was also caused by some imperfections in the machinery, and resulting in the breaking of a guide-arm to slide-valve rod, the piston terwards tappet arm of condensing pump; in the settling of the founda- ge pumps, necessitating the building under them of two additional bulk- in the small drift getting under the pump valves, thus destroying the he latter was the principal cause of lost time, but the trouble was finally y placing very fine screens over the ends of suction pipes.

nization of the party for this grader was as follows: 1 assistant engineer steam engineers, 2 firemen, 1 foreman, 3 nozzlemen, 3 deck-hands, 1 cook, ; fourteen men in all.

the wet and dirty work, the foreman and nozzlemen were provided with suits complete, including caps, boots, and gloves.

le was supported upon a stand consisting of a piece of gas-pipe firmly the ground, and well braced. To it was attached a piece of round iron, oot long, which passed into the pipe. This formed a universal swivel, arrangement being light and quickly removable. A long lever, clamped zle, rendered its direction easy, so that a large stream was manipulated the same facility as a small one.

ng, the nozzle was held as near to the bank as practicable, and the stream gainst it at angles varying from 45° to nearly 90°. The top part of the ut first, so as to allow the water to always flow along the face of the cut. ort experience the nozzlemen had no trouble in holding the face. The the bank was hard blue clay and buckshot, interspersed with layers of rial and sand, causing the banks to cave in steps.

es of nozzles 2, 1¾, and 1½ inch diameters were used, and two sizes of hose, 2½ inches diameters.

eated trials it was found to be best practice, in the hard material worked, nozzles, large hose, and but one stream. The water pressure at pump from 135 to 140 pounds per inch. I think better results could be obtained ill larger nozzles, as 2¼ to 2½ inches diameter. Experience in softer ma- sand shows best results from smaller nozzles and two streams.

er now used consists of a Dayton cam piston pump of the following di-

	Inches.
f steam cylinder	16½
f water cylinder	9
troke	18

y a boiler of dimensions as follows: 20 feet long, 42 inches diameter of ng two 14-inch flues. The whole is mounted on a barge 100 by 16 by 3½ ...e is 6 inches in diameter, and the discharge is through from 100 six-ply test hose, with nozzle of 1½ to 1¾ inch diameters, the at date the best results. The theoretical discharge is at date , the speed being 80 single strokes.

this grader is as follows: One steam engineer, one foreman, one ...en, and one deck-hand; seven in all.

During the month of September, 1883, I was obliged to keep water pressure down on account of the inferior quality of the hose; since then, with new 6-ply test hose, I have had on the pump a pressure of 240 pounds to the inch.

With grader No. 2 the slope cut was 3 to 1 from the water edge to the top of the bank. As the working capacity of the small grader was so much less, I have been obliged to grade to a greater slope, viz, 2 to 1 and 2½ to 1, being governed by nature of material, quantity to be removed, &c., and also to leave a vertical face, varying with the material, of from 6 to 12 feet. Under the head of "work done" will be found tables of results obtained with both graders.

WORK DONE TO NOVEMBER 1, 1883.

Preparations for commencing the work were made on December 6, 1882, by erecting quarters for the accommodation of 100 laborers, upon the bank near the upper end of the work, and by employing a small force to clear the bank of timber and brush. The entire length of the bend, a distance of over two miles, was cleared to an average width of 75 feet. Many large trees had fallen over the bank into the water, thus forming obstructions to the placing of mattresses. Your attention being called to this, you obtained the United States snag-boat H. G. Wright to remove them. Between December 7 and 14, 1882, she cleared about ½ mile of the bend.

On December 8, the steamer Emma Etheridge delivered the following plant: Hydraulic grader No. 2, two mattress boats, one machine-shop boat, one screen-boat, and one barge of coal.

Preparations were at once made to start the grading, which was begun on December 21, at which date, the quarters being finished, I commenced subsisting the men. Owing to the non-arrival of barges and quarter-boats for the brush party, the work of building mattresses was not begun until January 16, 1883, at which date Assistant Engineer Joseph Burney, who had charge of the work of protecting Memphis Harbor, commenced supplying me with brush. I obtained poles from bank clearing, and others by sending a party several miles up the river, they returning to the works at night.

From December 29, 1882, to January 15, 1883, the United States snag-boat Jno. R. Meigs was employed to tow willows, &c., to the works. At the latter date the chartered tow-boat H. M. Graham arrived and took the place of the Meigs.

MATTRESS CONSTRUCTION.

The construction of "deep-water mattress" was begun at Mound City ferry-boat landing on January 16, 1883, and continued until February 10; during which time 1,127 lineal feet of mattress, 140 feet wide, was constructed and sunk; 194 by 25 feet of foot-mattress and 194 by 16 feet of shore-protection were also completed.

The mattresses sunk were four in number and from 256 to 298 feet long; it being considered advisable to make short mattresses, on account of the rapidly-rising water and the great amount of drift running, much of which lodged against the mooring barge and caused a very heavy strain on the lines attached to it and to the mattress. The intention was to lap the mattresses by about 15 feet; but when sunk, owing to the drift pressure, gaps of this distance were found in two places instead of laps. There was used in the construction of the above 840.5 cords of brush, 105 cords of poles, 2,534 pounds of wire, 80 pounds of rope, 1,950 pounds of wrought spikes, 200 pounds nails, 585 cubic yards of stone, and 4,300 gunny-sacks. The latter were used to sink mattress No. 3, which was 298 by 140 feet in size; each sack was filled with about 120 pounds of buckshot clay, the total weight being equivalent to the weight of 214 cubic yards of stone. They cost when filled and loaded on barges about 9 cents each.

The depth of water in which mattresses were sunk was from 40 to 70 feet.

During the first ten days in February, 1883, the work was much retarded by bad weather. The water having risen from 7.50 feet on the Memphis gauge on January 16, to 23.30 feet on February 10, work was suspended on the latter date, the water being then on a level with the bank upon which quarters were located, and necessitating their removal.

The grading of the bank was begun December 21, 1882, and continued until January 31, 1883, when work was suspended on account of high water. During this time there was graded 1,793 linear feet of bank; 42,057 cubic yards of earth removed, at a cost of [illegible] cents per linear foot, or 4.03 cents per cubic yard. Table I, annexed to this report, will show in detail the work done.

On February 28, the tow-boat H. M. Graham was taken to Cairo.

From February 10 to August 6, 1883, no construction work was done, the water being too high. During this time a small force of mechanics were employed in getting barges, quarter-boats, &c., in readiness for this season's work.

On [illegible] 15, I received your verbal orders to prepare to resume work. The tow-boat Graham arrived on the 17th and was put in commission on the 20th.

A quarter-boat for brush party was at once fitted up and turned over to Joseph

, United States Assistant Engineer. This party began work July 26, on Dean's about 25 miles above. I received from them the first barge of brush on Aug- and began the construction of mattresses on August 6. After constructing 493 feet of mattress I deemed it expedient to sink it, as considerable drift had ac- ted above the mooring barge, and much of it was getting under the mattress. uently lengths of mattresses were increased to 900 and 1,000 feet. No trouble net in sinking mattresses of this length, it was decided (September 29) to con- continuous mattresses. The mattress now being built is 2,150 long, 1,580 feet ch has been sunk. No trouble whatever has been met in sinking part of the ss and keeping part afloat, nor do I apprehend any except from drift, in which attresses will have to be broken off and sunk when the drift causes excessive

willow party being insufficient to supply us, quarters for 70 men were erected rge, and a second party sent out on September 17. The water being too low tow-boat, both parties were withdrawn from Old River, west of Centennial on September 24, and placed in the main river, where brush was scarce, and eat distance from the river.

ctober 15 the river rose sufficiently to permit entrance to Old River, and both arties were moved there.

g short of brush, I organized a third party, and placed them on "Old Hen " just opposite the work. They are supplying at date 60 cords per day, our quirements being about 200 cords per day.

g to short supply of brush, no shore work was done until October 2, although derable portion of the bank had been staked out and wired ready to have the laced in position.

ugust 17 the snag-boat John R. Meigs began work in clearing the bend of She finished on October 11, having removed five hundred and forty-one nd ten rack heaps. Two men were lost by falling overboard.

eptember 24 a small flat, loaded with 600 bushels of coal, was struck by a large g and sunk.

following tables will show you the work done in detail:

TABLE No. 1.—HYDRAULIC GRADER No. 2.

Linear feet.	Cubic yards.	Average area of cross-section.	Time worked.	Yards cut per hour.	Average pressure.		Strokes per minute.	Coal.	Cost per cubic yard.	Cost per linear foot.	Composition of material.		
					Steam.	Water.					Buckshot.	Clay.	Sand.
		Sq. ft	Hrs		Lbs. pr. sq. in.			Bush.	Cts.	Dols.	Pr. ct.	Pr. ct.	Pr. ct.
175	4,620	700	51	90.6	95	135	32	600	8.3	2.21	45	55	....
385	7,022	475	42	167.2	95	135	32	625	5.5	1.01	45	45	10
595	16,034	730	77	208.0	98	140	33	995	2.8	0.75	40	30	30
638	14,411	640	85½	170.0	95	140	32	900	3.1	0.708	65	30	05
1,793	42,087	.....	255½	....	....	....	...	3,120	....	.....	....	....	....
......	....	.....	....	165.0	....	137.5	...	......	0.0403	0.94	49	40	11

TABLE No. 2.—DAYTON CAM PUMP.

1,205	4,150	.....	80	52	90	95	64	150	3.5	0.120	40	25	35
900	5,245	.....	90	58	90	95	64	175	2.9	0.170	16	30	54
655	4,105	.....	80	51	80	120	64	209	3.5	0.322	50	30	20
1,475	4,290	.....	82½	52	80	125	72	175	3.5	0.105	72	13	15
1,075	4,195	.....	82½	51	80	130	72	144	3.5	0.140	30	45	25
570	3,170	.....	60	53	80	135	82	108	4.0	0.244	No record.		
5,880	25,155	.....	475	....	....	....	....	971	....	.....	....	....	....
......	....	.....	....	53	....	....	....	......	3.5	0.150	....	....	....

RÉSUMÉ OF GRADER WORK.

...k graded 7,673
...th removed 67,242
.... $0.334
.... 0.038

—176

Mattress work done is as follows:

Mattress No. 1, sunk January 23, 1883	298′×140′	
Mattress No. 2, sunk January 27, 1883	275′×140′	
Mattress No. 3, sunk February 3, 1883	298′×140′	
Mattress No. 4, sunk February 10, 1883	256′×140′	
		1127′×140′
Mattress No. 5, sunk August 11, 1883	493′×140′	
Mattress No. 6, sunk August 23, 1883	850′×140′	
Mattress No. 7, sunk September 4, 1883	952′×140′	
Mattress No. 8, sunk September 15, 1883	925′×140′	
Mattress No. 9, sunk September 28, 1883	1032′×140′	
Mattress No. 10, sunk October 23, 1883	1580′×140′	
Mattress No. 10, afloat	570′×140′	
		6402′×140′
Total amount of deep mattress made		7529′×140′
Total amount of deep mattress sunk		6959′×140′

In addition to this there was made and sunk a mattress 100 by 300 feet to cover a cave in bank between mattresses Nos. 3 and 4, due to their not lapping.

At date (November 1) 6,700 linear feet of bank is covered by "deep-water mattresses," and 4,100 linear feet by "upper-bank protection." The total revetment is 120,918 square yards.

In preparing for work, the following (mostly heavy) timber was cleared from the bank:

	Acres.
From December, 1882, to February, 1883	16
From August, 1883, to November 1, 1883	9
Total clearing	25

Table showing material used in construction.

Material.	Deep-water mattress. January and February, 1883.	Deep-water mattress. August to November, 1883.	Upper bank protection.	Total.
Brush ... cords	840.5	4,885.0	938.0	6,663.5
Poles ... do	105.0	310.0	....	415.0
Wire ... pounds	2,535.0	18,072.0	4,176.0	24,783.0
Spikes ... kegs of 150 pounds	13.0	44.0	....	57.0
Nails ... kegs of 100 pounds	2.0	11.0	....	13.0
Stone ... cubic yards	565.0	3,703.0	454.0	4,722.0

I have on hand the following plant, viz:
One quarter boat, 130 by 25 feet, capacity 180 men.
One quarter-boat, 100 by 20 feet (double-decked), capacity 120 men.
One quarter-boat, 90 by 20 feet, capacity 60 men.
One quarter-boat, 82 by 18 feet, capacity 80 men.
One quarter-boat, 80 by 18 feet, capacity 24 men.
One quarter-boat, 60 by 16 feet, capacity 30 men.
Five small flats used in construction.
Four screen-barges, 100 by 25 feet.
Two mattress-ways, 160 by 30 feet.
One hydraulic grader-boat, 100 by 16 feet.
One machine shop, 130 by 24 feet.
One decked barge, 130 by 24 feet.
Twenty-three decked barges, 100 by 25 feet.
One decked barge, 100 by 18 feet.
Thirty-nine skiffs.

Very respectfully, your obedient servant,

W. M. REES,
United States Assistant Engineer.

Maj. A. M. MILLER,
Corps of Engineers, U. S. A.

l, for the time being, on account of high water, and, owing to the long con- of the same, was not recommenced until by your orders, on August 1. The this portion was then pushed slowly forward; the party consisting of myself men only, as on account of a lack of funds available at that time economy ssary.

latter part of August, as you were informed that an allotment had been made mpletion of the survey, the party was increased by the addition of a transit- several skiffmen, and the work further facilitated by the use of the steam- aphne.

the time of the completion of the survey, as originally projected, I received rs to continue it up the river to the foot of Island No. 40, an additional dis- 7½ miles, and soon afterwards received your further instructions to extend it river to Scanlan's Landing, a distance of 15¾ miles, making a total length of ong the main channel of 30 miles, and reaching from the foot of Island No. 40, above the foot of Jefferson street, Memphis, to Scanlan's Landing, 18¼ miles same point. This constitutes the survey as finally completed, and I will consider it as a whole.

e had been a very complete survey of almost the entire portion of this reach made in 1877-'78, under the direction of Lieut. Col. C. B. Comstock, Corps of s, United States Army, the primary object of the present resurvey was to the changes in the bed and banks since that time; that is, the location and f the erosion of the banks, the accretion or formation of bars, and the scour the bed of the stream.

METHOD OF MAKING SURVEY.

lete triangulation of the reach having been made, both under the direction l Comstock and by the Coast and Geodetic Survey (the notes of which were this office), and as most of their points were still intact it was not deemed to make an entirely new trigonometrical survey. Both for economy of time rder to make a more exact comparison with the previous survey, those old hich were found to be in good order were used in the new survey, and the ch had been destroyed and were necessary to insure the accuracy of the e replaced.

nk and bar lines between the triangulation stations were determined by easurements, as were also the sounding stations. Soundings were located ections from two transits on shore, usually placed on the bar or convex side er, so as to give the best angles of intersection.

l methods of making soundings were tried and the one most generally used was

THE CHARTS.

The map of the river submitted herewith consists of four charts, made to a scale of 1:10,000, numbered from one to four, beginning at the foot of Island No. 40. As probably the best method of describing the reach surveyed, I will take up the charts in numerical order, and consider them separately.

Chart No. 1 extends from the foot of Island No. 40 to Mound City Landing, a distance along the channel line of 7½ miles. Of this portion of the river, only that part had been previously plotted by the "Comstock survey" between the head of Old Hen Island and Mound City Landing. Heavy caving is shown to have taken place on the head of Old Hen Island, and the bar below has kept moving down the river, following the rapid caving in of Hopefield Bend. Above Mound City Landing, the caving on the right bank since the "Comstock survey" is inconsiderable. Above the head of Old Hen Island, the previous survey was made under the direction of the Mississippi River Commission, in 1879-'80. As their maps, plotted to a large scale, have not been furnished this office, I have not been able to place their shore-lines on the new maps. Throughout the reach of river on this chart, the width between bank lines is excessive, varying from 3,000 to 6,000 feet; but, at the stage to which the chart is plotted, the widths of the water-way are as follows: 3,000 feet at foot of Island Forty, thence contracting to 2,000 feet in next three miles, and again widening to 5,000 feet at head of Old Hen Island.

The soundings and shore-lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 11.4 feet on the Memphis gauge.

Chart No. 2 extends from Mound City Landing to the head of President's Island, a distance along the channel line of 7 miles, and includes the river-front and harbor of Memphis.

The most noticeable change shown to have taken place on this portion of the river is the heavy caving above Hopefield, extending from Mound City Landing to Hopefield, and amounting to a maximum cutting of 1,200 feet, in the middle of the bend, since the survey of 1877-'78. Rapid caving is also taking place on the left bank above Wolf River. This caving, by comparison of more recent surveys, seems to be increasing in rapidity. Gradual caving is also shown to have taken place on the river-front of Memphis, above Jefferson street. This portion of the front has been partially revetted during the past four or five years, and the caving thereby stopped, or at least checked, as considerable caving of the top bank has taken place during the past year, which, although not showing largely on this map, is of considerable importance on account of the value of the property affected.

The water-way in front of Memphis and in a part of Hopefield Bend is contracted to a width of only 1,600 or 1,800 feet, at the stage of water to which the chart is plotted. This chart also shows the sweep of the bend opposite Memphis and the course of Four-mile Bayou, extending almost across it. The shortest distance through this bend is 13,600 feet.

The soundings and shore lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 11.4 feet on the Memphis gauge.

Chart No. 3 includes the whole of President's Island, and shows the main channel and chute on either side of it. The nearly equal division of the low-water discharge of the river at the head of the island has apparently been the cause of shoaling and contracting the low-water channel of the main river along its north and west sides.

Between the mouth of Four-mile Bayou and Lake's Landing, the width of the water-way, at the stage to which the chart is plotted, is only 1,300 feet. Below Lake's Landing it widens out, but becomes shoal, and by the formation of a middle bar, one mile above Rowley's Landing, the actual available channel is contracted to 600 feet, and maintains this width for 2,000 feet. The clear high-water width of the main river averages from 4,000 feet to 5,000 feet, exclusive of the chute between President's and Vice-President's Islands.

The principal caving shown to have taken place in this portion of the main river extends from the head of the Apperson plantation to Jones's Landing, where there has been an average cutting of from 400 feet to 500 feet, for a distance of 10,000 feet. Caving has also taken place immediately above Lake's Landing, averaging 200 feet in width by one-half mile in length, and from the mouth of Four-mile Bayou, upstream, there has been an average caving of 150 feet for a distance of a mile.

The chute to the east and south of President's Island has a very uniform width between bank lines, varying only from 2,000 to 2,200 feet. At low stages its width in the bend is contracted by a bar to 1,200 feet, and a middle bar, or reef, also obstructs the upper end of the chute, for a distance of about a mile. From the lack of necessary tools and appliances for making the examination I was not able to judge of the nature of the material of which this reef is composed; but the bottom of the whole upper portion of the chute, as indicated merely by the feel and effect upon the sounding-lead, seems to be of a hard, gravelly nature. From the foot of

he bluff, at the head of the chute, a reef of ferruginous sand-rock juts into the stream, howing at a stage about 10 feet above low water; and this middle bar may possibly e of the same nature. In this connection, from the report of Assistant Engineer E. H. Wilson to the secretary of the Mississippi River Commission (June, 1881), I find the following information concerning the nature, depth, and probable location of this rock. At boring No. 1, located at the foot of the bluff, about three-fourths of a mile below the head of the chute, ferruginous sandstone stopped further progress at a depth of 107.4 feet below the top of the bluff, which, according to his diagram, would be about on a level with the low water of 1872.

In describing this boring Mr. Wilson says: "The sand rock which stopped the progress of the boring, it seems, is here of unusual extent, appearing above the water at low stages of the river some distance from the bank, which, washing away the overlying material, has been unable to remove the rock. * * * It seems possible that the submerged bar which extends from this point to the head of President's Island, may be an extension of this sandstone layer."

With the exception of the middle bar referred to, I did not find any shoal of a possible rocky formation in the stream, which would appear above the water at its lowest stage. At two points in the chute, where some disturbing elements on the bottom (claimed by some to be rock reefs) have caused large boils on the surface, there was found not less than 19 feet of water at the stage sounded—6.5 feet on the Memphis gauge.

The supposition as to the rocky nature of the middle bar may, very likely, be correct; but a thorough examination is necessary, in order to establish it as something more than a mere hypothesis.

The distance through the chute is 1¼ miles shorter than by way of the main river at low stages of water; the length of the main channel being 7¾ miles, and by way of the chute, 6½ miles.

The principal caving shown to have taken place in the chute is at the head of President's Island, where there has been an average cutting of from 200 feet to 500 feet for a distance of a mile; and also on the foot of the island averaging 300 feet in width by one-half mile in length. Slighter caving, varying from 50 feet to 100 feet in width by two miles in length, has also taken place on the Tennessee shore below Nonconnah Creek.

The soundings and shore lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 6.5 feet on the Memphis gauge.

Chart No. 4 extends from the foot of President's Island to Scanlan's Landing, a distance along the channel of 8 miles.

The width of the river between banks throughout almost the whole of this reach is very excessive, being from 5,000 to 6,000 feet.

From Reeves' Landing to Harris' Landing, where the width from bank to bank is 6,000 feet, a middle bar has formed, which, at low water, divides the river into two channels, both of which are navigable for small boats of light draught, the one on the right, however, being the main channel and the only one through which large boats can pass with any degree of safety.

The bars at Hampton and Scanlan's Landing have been found to be greatly increased in size and are gradually moving down stream. The width of water-way of the main channel, as contracted by the bars at the stage of water at which the survey and map were made, is 2,600 feet at Ensley's plantation, 4,000 feet at Hampton Landing, 1,700 feet at Reeves' Landing, keeping about this width to Harris' Landing, then widening to 5,000 feet on the crossing below, but soon contracting again to 2,500 feet and keeping about this width to near Scanlan's Landing.

The principal caving found on this reach is at the following points: Between Reeves' and Harris' Landing where, for a distance of 4,000 feet, there has been an average cutting of 300 feet; below Fleece's plantation, where there has been a cutting of 200 feet to 400 feet, a distance of 3,600 feet; and on the head of the old Cow Islands, where the caving has been from 200 feet to 600 feet in width, by a mile in length.

Slight and inconsiderable caving has also taken place on the lower end of Ensley's plantation, between Horn Lake and Collins' Landings, and below Scanlan's Landing.

The soundings and shore lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 6.5 feet on the Memphis gauge.

SLOPE OF THE RIVER.

While the party was at Hampton Landing, a daily gauge record was kept at that point, the zero of the gauge being connected with that at Memphis, by means of the levels of the "Comstock" survey. In the following table are given the daily gauge readings at both points from November 30 to December 13, the zero of the Hampton gauge being reduced to the same level as that at Memphis. The daily differences in level and slope per mile are also given. Taking from this table 0.5308 foot, the average slope per mile, and multiplying by 7¾ miles (the distance around President's

[…]ver of the main channel), we get 3.8483 feet as the difference in […]ad and foot of the island; and, dividing this by 6¼ miles, the di[…]ate, gives 0.5920 feet as the average slope per mile through the […]

Table of slopes.

Date.	Gauge readings.		Distance.	Difference in level.	Slo[…]
	Memphis.	Hampton Landing.			
1882.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
November 30	6.35	−0.24	12¼	6.59	
December 1	6.30	−0.24	12¼	6.54	
December 2	6.25	−0.26	12¼	6.51	
December 3	6.30	−0.31	12¼	6.61	
December 4	6.30	−0.31	12¼	6.61	
December 5	6.40	−0.26	12¼	6.66	
December 6	6.40	−0.26	12¼	6.66	
December 7	6.45	−0.31	12¼	6.76	
December 8	6.60	−0.26	12¼	6.86	
December 9	6.80	+0.09	12¼	6.71	
December 10	6.60	+0.09	12¼	6.51	
December 11	6.50	−0.11	12¼	6.61	
December 12	6.25	−0.31	12¼	6.56	
December 13	6.00	−0.71	12¼	6.71	

DISCHARGE OBSERVATIONS.

In order to ascertain the relative amounts of water passing on either side of […]dent's Island, discharge observations were taken in both the chute and main r[…] short distance below the head of the island, on the following days, December […] 31, 1882, January 2 and February 20 and 21, 1883. The results of these observ[…] are given in the following table:

Table of discharges.

Date.	Memphis gauge reading.	Main channel.				Chute.				
		Area of section.	Discharge per second.	Mean velocity.		Area of section.	Discharge per second.	Mean velocity.		
				Per second.	Per hour.			Per second.	Per hour.	
1882.	*Feet.*	*Sq. feet.*	*Cubic feet.*	*Feet.*	*Miles.*	*Sq. feet.*	*Cubic feet.*	*Feet.*	*Miles.*	*Cu[…]*
Dec. 29	8.35	29.435	[illegible]	3.849[illegible]	2.6243	39.264	183.181	4.6654	3.1810	
Dec. 31	9.80	32.817	123.965	3.7753	2.5741	42.362	199.497	4.7093	3.2109	
1883.										
Jan. 2	10.40	34.035	139.071	4.0861	2.7860	43.394	206.573	4.7604	3.2457	
Feb. 20	32.80	141.467	618.268	4.[illegible]	2.9811	104.519	545.738	5.2503	3.5798	1,
Feb. 21	33.30	143.944	641.346	4.[illegible]	2.9413	105.733	562.715	5.3220	3.6286	1,

From the above table it will be seen that on December 29 and 31, 1882, and Ja[…] 2, 1883, when the water was at a medium low stage, the discharge through the […] was about sixty per cent. greater than through the main river, but on Febru[…] and 21, when the river was bank full, the discharge through the main chann[…] about 10 per cent. greater than through the chute.

These observations were made with floats, running a distance of 200 feet.

The floats were of the same pattern as those used by this office in making dis[…] observations in 1879.

Very respectfully, your obedient servant,

F. S. BURROWES,
Assistant Engi[…]

Capt. A. M. MILLER,
Corps of Engineers, U. S. A., Memphis, Tenn.

K 4.

F F. A. FISHER, ASSISTANT ENGINEER, UPON A SURVEY OF THE HELENA REACH.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., *May* 31, 1883.

R: I have the honor to present to you the following report of the survey of a Reach, Mississippi River, you intrusted to my charge during the season 3:

rdance with your letter of instructions, dated October 16, 1882, I at once or- party and procured the necessary outfit. The party consisted of one assistant in charge; two sub-assistants; four rodmen; one leadsman; seven oarsmen, ook; the quarter-boat being just large enough to accommodate that number I left Memphis October 22, 1882, allowing the boat to drift and piloting it two well-manned skiffs to Commerce Landing, arriving October 24.

truments furnished me were: Transit No. 4840 (Heller and Brightly); transit rley); level No. 4918 (Heller and Brightly).

rvey comprised a tertiary triangulation, shore line of both banks, of bars, s, islands, and topography of same; soundings and necessary level connec- ween United States bench-marks and gauges; and, also, according to further ns, dated November 25, 1882, location of levees along the river, when it did d the survey too far, and the ascertaining the level of high water of 1882.

ary triangulation station "Peters," being the only one near the beginning rk which could be found, observations for azimuth were made near Com- nding, and the triangulation carried from a carefully measured base-line, in length, connecting this point with triangulation station "Peters," to a e at the head of Bordeaux Chute, where observations for azimuth were also a check on previous determination.

. K. Landing, Miss., the first complete connection with secondary triangula- gh line triangulation station O. K—triangulation station Waddell, azimuth 7".54, was made. My observed azimuth checked within one minute. The nection was made at Helena, Ark., with line triangulation station Battery —triangulation station Court-house, and again at Friar's Point, through line tion station Ship—triangulation station Westover.

to determine river slope, were placed at such points along the river as indicate a change of inclination; and, elevation of their zeros was deter- levels from known elevation of United States bench-marks. A number of ted States bench-marks were connected by chain and transit with tertiary tion points.

aneous readings of the gauges were taken at two points, usually for six hours sion, and days selected for slope determination at a nearly stationary stage er. The result, with dates when observed and stage of river at Helena, are Table No. 1. The rate of caving of banks on the "reach," for the time the surveys of 1878–'79 and 1882–'83, is given for the different sections in . 2. Sand-bars have not been considered in this estimate.

vel of high water of 1882 is given in Table No. 3. The stage of water at Mem- n., and Helena, Ark., is given in Table No. 4. The amount of work done is Table No. 5.

TOPOGRAPHY.

"reach" many of the secondary stations have been washed away; in some plowed up, and in others buried under mud, and sand, some 2 or 3 feet ertiary points were substituted and placed in close proximity to each other, void the cutting of heavy timber. Stadia lines were run between stations, oints inland taken as far as stadia could be read. Elevations as given on the gend, in feet, on a plane which is 225 feet below high water of June, 1858. h water corresponds to a reading on Memphis gauge of 34.16 feet.

SOUNDINGS.

nding, a lead weighing 17½ pounds was used. The original lead weighed 20 but I found it too heavy for satisfactory use, so I reduced its weight as given The lead-line measured 100 feet; the actual length of which was determined ndard measure at all times before its use, and correction noted in its proper sounding-books.

lly, lines were sounded at an interval of about 1,000 feet, but at less distance r the river bed appeared changeable. Two transits occupied such triangula-

[illegible] determination of position of sounding-boat was [illegible]

[illegible] expressed in feet and are reduced to that stage of water [illegible] of 12.58 feet on the Helena gauge; being the mean [illegible] soundings were taken. The elevation of this stage of water [illegible] United States bench mark [illegible]. High water of 18[illegible] [illegible] the stage of water to which the charts are reduced. [illegible] indicate the days on which soundings were taken. [illegible] Helena gauges on these days are given in Table [illegible] [illegible] during the day, at 9.30 a. m. and 1.30 p. m. The [illegible] [illegible] were taken.

CAVING BANKS.

[illegible] localities and the rate of caving. The rate is determined [illegible] present position of the shore-line with its position at former [illegible] that the caving at east side of Bordeaux Island is going [illegible] 1,100 feet in one year; and as the whole distance across [illegible] Walnut Bend Landing, is only 1,117 feet, the river will doubt[illegible] break through and resume its original bed in Walnut [illegible] this report a reduced plot of this interesting section of river.

BARS AND TOW-HEADS.

[illegible] Landing, between old and new river, has extended [illegible] half of a mile, and is composed of a very fine and easily [illegible] northern portion, where a small belt of gravel pre[illegible] [illegible] is some silt and mud. The opening at Linwood [illegible] is closing rapidly. The bar immediately below, on Missis[illegible] [illegible] of sand with some silt at extreme southern end [illegible] into this bar and has lost its identity.

[illegible] Landing, "Ashley Point," is, at its highest elevation, [illegible] the bluff or main shore, gravel exists and varies in size [illegible] coarse sand.

[illegible] Bordeaux Chute consists of a very fine sand; the southern [illegible] joins on the main shore, is composed of mud.

[illegible] extended down stream three-fourths of a mile, with fine [illegible] however, at a depth of one or two feet, it becomes [illegible] pebbles as much as 0.75 inch in size.

[illegible] near future, become, no doubt, an island, as the river above is [illegible] the old Walnut Bend Channel.

[illegible] above O. K. Landing, as well as two small bars [illegible] coarser kind of sand than usually found; probably [illegible] varies from 0.04 to 0.05 inch in size.

[illegible] this bar. At its eastern extremity, where it [illegible] is a belt of mud which extends up as high [illegible] sand bars, as well as shore bar opposite O. K. [illegible] mud surrounding them. The island imme[illegible] [illegible] consists of coarser sand mixed with large [illegible] size.

[illegible] Landing are composed of fine sand. Shoo[illegible] [illegible] body with some gravel at its northern [illegible] shape since 1878. From being egg-[illegible] [illegible] stream, it has assumed a long, narrow shape [illegible] has extended to 1¼ miles below its former [illegible] well. The main channel of river [illegible] Arkansas side and passes close to north [illegible] Mississippi shore has a tendency to fill. [illegible] which includes at the present time [illegible] sand. The tow-head itself is composed of [illegible] former channel between tow-head

[illegible] large dimension, closing the former exist[illegible] [illegible] entirely. The northern part of [illegible] sand. At the eastern slope of [illegible] 0.5 inch occur. The southern part [illegible] along water edge. Helena Tow-head is [illegible] and also along eastern edge, where [illegible] heavy growth of willows and cottonwood.

K 2.

OF F. S. BURROWES, ASSISTANT ENGINEER, UPON A SURVEY OF THE MISSISSIPPI RIVER IN THE VICINITY OF MEMPHIS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 12, 1883.

…IR: I have the honor to submit the following report upon the survey of the …ppi River, in the vicinity of Memphis, made under your instructions during … year.

…rvey was begun May 5, 1882, under the direction of your predecessor, Maj. … Benyaurd, Corps of Engineers, United States Army, and at that time was …d to include only that portion of the river from Mound City Landing to the … President's Island, a distance of 7 miles. Ten days after field work was dis…ed, for the time being, on account of high water, and, owing to the long con…e of the same, was not recommenced until by your orders, on August 1. The … this portion was then pushed slowly forward; the party consisting of myself …e men only, as on account of a lack of funds available at that time economy …essary.

… latter part of August, as you were informed that an allotment had been made …mpletion of the survey, the party was increased by the addition of a transit… several skiffmen, and the work further facilitated by the use of the steam… Daphne.

… the time of the completion of the survey, as originally projected, I received …ers to continue it up the river to the foot of Island No. 40, an additional dis… 7½ miles, and soon afterwards received your further instructions to extend it …e river to Scanlan's Landing, a distance of 15½ miles, making a total length of …long the main channel of 30 miles, and reaching from the foot of Island No. 40, …s above the foot of Jefferson street, Memphis, to Scanlan's Landing, 18¼ miles …e same point. This constitutes the survey as finally completed, and I will …e consider it as a whole.

…re had been a very complete survey of almost the entire portion of this reach made in 1877–'78, under the direction of Lieut. Col. C. B. Comstock, Corps of …s, United States Army, the primary object of the present resurvey was to … the changes in the bed and banks since that time; that is, the location and …of the erosion of the banks, the accretion or formation of bars, and the scour … the bed of the stream.

METHOD OF MAKING SURVEY.

…plete triangulation of the reach having been made, both under the direction …al Comstock and by the Coast and Geodetic Survey (the notes of which were …d this office), and as most of their points were still intact it was not deemed …y to make an entirely new trigonometrical survey. Both for economy of time …rder to make a more exact comparison with the previous survey, those old …hich were found to be in good order were used in the new survey, and the …ich had been destroyed and were necessary to insure the accuracy of the …re replaced.

…ank and bar lines between the triangulation stations were determined by …easurements, as were also the sounding stations. Soundings were located …sections from two transits on shore, usually placed on the bar or convex side …ver, so as to give the best angles of intersection.

…l methods of making soundings were tried and the one most generally used was …as giving the greatest number in a given time. A skiff, with three oarsmen, …an, and a recorder, was rowed rapidly back and forward across the stream … lead cast every half-minute. Every second sounding being located by the …en sighting on a flag raised and quickly lowered by the recorder at the in… sounding. In order to keep a check on the numbers the flag was quickly …d lowered twice at every fifth sounding, and such double flag noted by both …en and recorder. On account of its too great draught the steam-launch was … be of very little utility in the actual taking of soundings at a low stage of … It was, however, used to a considerable extent in the immediate vicinity of …, the soundings over this portion being taken in longitudinal lines. The lead … but once for each line and the launch and lead-line kept drifting together. …gs were taken every fifteen seconds and every fourth sounding located. This … without doubt, gives the most accurate results, but was abandoned on ac… the great length of time consumed.

Bel… … en a list of localities and the rate of caving. The rate is determin… from a co… ison of the present position of the shore-line with its position at form… survey.

TABLE No. 2.—*Caving banks.*

Locality.	Rate of caving per year.	Total caving.	Material.	Remar…
	Feet.	*Feet.*		*Since*
Ashley Point, Ark	320	640	Sand	Dec.,
Mhoon's Landing, Miss	250	500	Sand and silt	Dec.,
Bordeaux Point Landing, Miss	400	800	Sand	Dec.,
Bordeaux Island (east side)	1,100	2,200	Clay and sand	Dec.,
Shore opposite Walnut Bend, Miss	400	800	Sand	Dec.,
Smith's Landing, Ark	540	1,080	....do	Jan.,
One and a half miles above Harbert's Landing	132½	530	Clay and sand	Nov.,
Opposite Shoo-Fly Bar, Ark	327½	1,310	Sand and silt	Dec.,
Mouth of Saint Francis River	75	300	Clay and sand	Dec.,
Below mouth of Saint Francis River	182½	730	....do	Dec.,
Trotter's Landing, Miss	312½	1,250	....do	Dec.,
Glendale, Miss	62½	250	... do	Dec.,
One and a half to 5 miles below Helena, Ark	250	1,000	Silt and sand	Dec.,
Delta, Miss	162½	650	....do	Jan.,
One and a half to 2½ miles below Friar's Point, Miss	140	280	... do	Feb.,

TABLE No. 3.—*Elevation of high-water marks of* 1882.

Locality.	Elevation.	Distance.	High-water slope per mile.	High-water slope for the distance.	Description of marks.
	Feet.	*Miles.*	*Feet.*	*Feet.*	
At Dr. Peters' store, opposite Commerce Landing.	209.43	......	......	......	This mark is defined by a nail dr… in the side of the counter insid… store.
Mhoon's Landing, Miss	208.13	5	0.260	1.30	Mark on tree, close by B. M. 4.
Bordeaux Point Landing, Miss	207.49	3	0.213	0.64	Mark on house of Henry Wilson.
Walnut Bend Landing, Ark	204.70	4	0.697	2.79	Two nails in door-post of store.
Austin, Miss	202.75	......	......	......	Height above bench mark on co… court-house square, measured… county surveyor.
O. K. Landing, Miss	202.60	7	0.300	2.10	Mark on store and post-office.
Mouth of Saint Francis River	200.63	8.75	0.225	1.97	Mark on large tree opposite post-o…
Helena, Ark	195.88	9	0.528	4.75	Mark on window-sill of brick b… opposite elevator.
Westover, Ark., opposite Friar's Point.	188.71	12.5	0.575	7.17	Well-defined mark on storehous… corner of levee.
Total	......	49.25	......	20.72	Entire high-water slope.

NOTE.—Elevations as given in this table depend in feet on a plane which is 225 feet below high w… of June, 1858. This high water corresponds to a reading on Memphis gauge of 34.16 feet. High w… of 1882 corresponds to a reading on Memphis gauge of 35.15 feet, and on Helena, Ark. guage of … feet.

TABLE No. 4.—*Water gauges.*

[Showing stage of water at United States gauge at Memphis, Tenn., and Helena, Ark.]

Date.	Mean elevation of water in vicinity where soundings were taken.	Gauge reading at Memphis at 8 a. m.	Gauge readings at Helena at 9.30 a. m. and 1.30 p. m.	Mean of Helena gauge.
1882.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Nov. 3	177.13	5.22	10.55 10.70	10.63
4	177.13	5.22	10.60 10.70	10.65
13	177.46	6.18	11.55 11.70	11.62
20	174.50	7.20	12.90 12.11	12.50
24	174.98	6.75	12.75 12.80	12.77
Dec. 5	174.43	6.40	12.10 12.10	12.10
9	174.43	6.80	12.20 12.30	12.25
11	174.43	6.50	12.50 12.60	12.55
15	167.80	5.25	11.10 11.00	11.05
20	166.78	3.75	9.00 8.11	8.55
21	165.74	3.50	8.75 8.80	8.77
29	168.02	8.20	13.05 13.30	13.17
1883.				
Jan. 5	162.08	10.00	17.10 17.10	17.10
6	162.08	9.70	17.00 16.11	16.55
15	162.08	7.50	13.20 13.30	13.25
16	162.08	7.50	13.50 13.60	13.55
17	160.90	7.55	13.65 13.80	13.72
23	163.15	10.25	15.80 16.00	15.90
24	165.22	11.00	16.80 17.10	16.95
Mean for nineteen days				12.82

BLE No. 5.—*Showing amount of work done from Commerce Cut-Off to Friar's Point.*

ary triangulation stations built	185
uths observed	3
s chained	3
dolite pointings	4,996
s cast, number of	6,184
r-gauges set	11
ography in miles along river channel, old and new	59
e-line in miles	135
bars surveyed, number of	41
r slopes determined, number of	9
s of levels run from United States bench-marks to connection with gauges	10.5

K 5.

ESTIMATE OF RICHARD KLEMM, ASSISTANT ENGINEER, FOR REBUILDING AND REP ING LEVEES, SAINT FRANCIS AND PART OF YAZOO FRONTS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 15, 188

CAPTAIN: I have the honor to submit to you herewith estimates of amount cubic yards to be filled, and also the number of acres to be cleared for the repair and rebuilding of the old State levees along the "Saint Francis front" on the w bank of the Mississippi River and the "Yazoo front" on the east bank of the riv

The Saint Francis front in this district extends on the Arkansas side from No. 40 to the mouth of Saint Francis River, and the Yazoo front, as far as sur from the Chickasaw Bluffs, below Memphis, to Friar's Point, on the Mississip

In accordance with your orders, I have prepared two estimates—one to g amount of cubic yards needed to fill the gaps and breaks in the old levees, and give the amount of cubic yards needed to raise all levees 1½ feet above high w 1882. The slope for new levees is calculated at 3 to 1 on the river side and 2 t the land side. The crown of the levees equals the fill up to a fill of 8 feet; 8-feet fill the crown will not exceed 8 feet. The muck-ditch is 4 feet wide on top wide at the bottom, and 3 feet deep. At such places where previously no leve been built, the calculations were made to a height of 1½ feet above high water for both estimates.

The estimates are compiled partly from actual surveys made by Mr. Gartie myself, and partly are taken from the charts made under the direction of G Comstock in 1878. From a point below Commerce, in Tunica County, to the Co County line, the amounts are taken from notes and profiles made by the county neer of Tunica County, Mr. G. W. Owens, and from Coahoma County line to F Point, in Coahoma County, from notes and profiles made by Levee Inspector Wi Hewson.

The high-water marks are partly from my own survey and partly from Assi Engineer Hunter Stewart. In locating the new levees, I followed the line of the levees as near as possible. At such places where the old levees had caved int river, I laid the new levees far enough back to probably be safe for some tim attach a sketch on tracing linen, showing the old levees, and also showing, in red the proposed line of the new levees. The map shows that all the old levees constructed to protect the farming interests only, and that the distances betwee levees on either side of the river vary from 1 to 6 miles.

I find that the highest ground is always along the river bank, and that most o surface drainage goes towards the inland; on the Arkansas side, to the Saint Fr River basin, and on the Mississippi side towards the Coldwater and Yazoo basin

Totals.

Location.	To height of old levees.	To 1½ feet above high water, 1882.	Clearing.
	Cubic yards.	*Cubic yards.*	*Acres.*
Arkansas side	1,188,126	1,684,153	678
Mississippi side	662,782	842,082	243

* * * * * * *

Very respectfully, your obedient servant,

RICHARD KLEMM,
Assistant Engin

Capt. A. M. MILLER,
Corps of Engineers, U. S. A., Memphis, Tenn.

1.—*Estimates for repairing and rebuilding the old State levees along the Mississippi River, on the Saint Francis front, in the State of Arkansas.*

From—	To—	Distance.	To height of old levee.	To 1¼ feet above high water, 1882.	Muck-ditch.	Clearing.
		Miles.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Acres.*
...int (...ty Breaks.)	Mound City	5	53, 092	174, 691	6, 699	46
... (...Breaks.)	Four-Mile Bayou	9	76, 357	211, 738	5, 520	65
...you (...and Reeves' Landing ...)	Scanlan's Landing	13	24, 773	178, 379	3, 732	......
...nding (...d Bend Breaks.)	Cat Island Landing	7	29, 990	60, 921	5, 412	80
...anding (...Breaks.)	Blue's Point	13	148, 758	153, 268	6, 999	84
... (...end Break, No. 1.)	Head of Council Bend	5	203, 537	203, 537	6, 993	80
...ncil Bend (...end Break, No. 2.)	Dr. Peters'	6	183, 953	183, 953	5, 406	74
... (...oint Levee.)	Head of Walnut Bend	5	100, 385	100, 385	8, 949	27
...nut Bend (...end Breaks.)	Fall's Place	8	160, 616	160, 616	5, 751	80
... (...oint Levee.)	Mouth of Saint Francis	7	140, 539	140, 539	10, 665	142
...	...	78	1, 122, 000	1, 568, 027	66, 126	678

. 2.—*Estimate for repairing and rebuilding the old State levees along the Mississippi River, on the Yazoo front, in the States of Tennessee and Mississippi.*

From—	To—	Distance.	To height of old levee.	To 1¼ feet above high water, 1882.	Muck-ditch.	Clearing.
		Miles.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Acres.*
...Lake (...om General Comstock's ...)	Abbey's Field	28	82, 272	82, 272	7, 620	24
...ld (...om G. W. Owens.)	Austin	20	295, 204	406, 683	5, 500	120
... (...W. Owens.)	Coahoma County Line.	17	223, 688	274, 761	4, 120	81
...unty Line (...illiam Hewson.)	Friar's Point	14	44, 298	60, 046	1, 030	18
...	...	79	645, 462	823, 762	18, 270	243

TABLE No. 3.—*High-water marks*, 1882.

ARKANSAS.

Location.	Station.	Elevation.	Remarks.
		Feet.	
...anding	0	229. 62	Taken by J. Gartland.
	156+75	228. 68	Do.
[illegible]	246+75	227. 85	Do.
...ling	830	224. 81	Taken by H. Stewart.
...r's	1030	222. 226	Do.
...ling	1260	221. 060	Do.
...anding	1430	219. 771	Do.
[illegible]	3050	209. 40	Taken by R. Klemm.
[illegible]	....	204. 67	Do.
[illegible]	....	200. 63	Do.
[illegible]	....	195. 88	Do.

TABLE No. 3.—*High-water marks, 188[illegible]*—Continued.

TENNESSEE AND MISSISSIPPI.

Location.	Station.	Elevation.	Remarks.
[illegible] Water Gauge		225.9[illegible]	Taken by [illegible]
[illegible] Landing		221.77[illegible]	Do.
[illegible] Landing	5[illegible]0	216.217	Do.
[illegible] Landing	10[illegible]0	211.22[illegible]	Do.
[illegible] Landing	1360	210.44[illegible]	Do.
[illegible] Landing		208.11[illegible]	
[illegible] Point		206.79[illegible]	
[illegible] Landing		202.86[illegible]	

APPENDIX I.

REPORT OF CAPTAIN W. L. MARSHALL, CORPS OF ENGINEERS, UPON OPERATIONS [illegible] THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., November [illegible], 18[illegible].

SIR: I have the honor to transmit herewith my reports of operations for the work in my charge in the Third District, Improvement of the Mississippi River, under the supervision of the Mississippi River Commission, for the eleven months ending November 1, 188[illegible], as follows:

1. Report on Lake Providence Reach, with sub-reports of Assistant Engineers [illegible] [illegible] Hider and J. E. Turtle, with nine plates. (I to IX.)
2. Report on revetment at Delta Point, La., and dredging in Vicksburg Harbor, with sub-report of Assistant H. St. L. Coppée, and four plates. (X to XIII.)
3. Levees.—Tensas and Yazoo fronts, with sub-reports of Assistant Engineers [illegible] [illegible] and George M. Helm, with wood-cut plates.
4. Survey of Choctaw Bend Reach, with sub-report of Assistant Engineer Wm. [illegible] [illegible].

I am, sir, very respectfully,

W. L. MARSHALL,
Captain of Engineers.

[illegible] SMITH S. LEACH,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

LAKE PROVIDENCE REACH.

[illegible] from Carolina Landing, 517 miles below Cairo, to the foot of [illegible] 8 miles. Work was begun under the appropriation of March [illegible] 188[illegible], and, with a short intermission in July and August, 18[illegible], has [illegible] since that time.

[illegible] the reach are sharp bends and very deep water and rapidly [illegible] the reach; eight crossings from bank to bank, [illegible] water was found at low water in years prior to the [illegible] miles of straight river, from Island [illegible] to foot of [illegible] the river at Skipwith Island [illegible], head of Stack [illegible]. In the latter bend the width of river at high [illegible] the channel is very much obstructed by shifting sand [illegible]

[illegible] the [illegible] and fixing permanently the [illegible] and show [illegible] of the width of the river is approxi[illegible]

[illegible] the closing of the following chutes is nec[illegible]

[illegible] feet in width at high water; [illegible] chute [illegible] of bar 1,200 to 1,800 fe[illegible] [illegible] chute, to new shore-lin[illegible]

[illegible]

te of the last annual report, works had been inaugurated for the closure , Island 93, Baleshed, and Stack Island Chutes, and also the revetment head of Island 93.

he past year work has been directed towards the completion of these works, been greatly extended, and to the inauguration of the revetment work at int, and contraction works at Elton or Hopewell Bar.

1.—REVETMENT AT PILCHER'S POINT.

s known as the Carolina, and Louisiana or Bunchs Bend, at the head of exhibit more rapid caving of the banks than any part of the reach, and the the changes produced in the direction of currents below is plainly seen The entire length of caving bank in the two concave bends approximates . In the Louisiana Bend at Pilcher's Point, since December, 1881, the cav- n such that the Mississippi low-water shore-line now occupies in places the the Louisiana shore-line then, or the river has caved its entire low-water ng two high-water seasons, or about 1,500 feet. The water is excessively ing to 100 feet in depth at low water. The effect of this caving has been s currents against the Mississippi shore above the contraction works at to partially undermine and destroy these works at the head of the chute, nger the works located in Skipwith Chute itself.

1882, a party was organized under Assistant Engineer Willard, who was relieved by Assistant Turtle; the wooded banks cleared, and preparations ginning the mattressing of the banks there. After the decline in the river mattress-work was started, but during the sickly season no progress could s labor was too scarce to supply the works already in progress and incom- ce October 1, the party has been increased, a snag-boat secured from Major move the snags from the bank to be mattressed, and about one-half mile of ork made, 1,228 linear feet of which has been sunk. This work, however, must be completed or made secure, on account of lack of funds, must now ped.

2.—FROM DUNCANSBY TO STACK ISLAND.

ision of the work has been, during the year, under the local management t Engineer Arthur Hider, who submits a detailed report of operations, with sketches appended hereto.

3.—DUNCANSBY SYSTEM.

tem embraces the first work of contraction on the reach. The river is here two tow-heads, or dry sand-bars, into two channels, the deeper of which is on ana shore. The object of the silting works built here is to close the chute sissippi side of the tow-heads; and at the head of the tow-head and in the te five cross-dikes, the upper three of which were provided with foot-mats s, the two lower with screens only, have been built.

gitudinal dike between the tow-heads was driven at high water and was ily a high dike. The works in the chute and at head reached only to the ge of water.

e rise in February the water was thrown against the head of this system by bend at Pilcher's Point, and parts of the upper dikes were washed out, but rked and decided fill occurred behind the remnants of the cross-dikes and al dike, between the tow-heads, the former of these, before being broken, idently offered sufficient resistance to determine the channel to the west of ads as desired. Along the longitudinal dike sand was piled up to the top ng in a very short while, and a rapid cutting away of the head of the upper resulting from the river crossing above it, set in.

nst a threatened water-way at low water through the Skipwith Chute, and head of the tow-head, pile-driving was resumed at the head of the island e chute April 4, 1883. Cross-dikes were driven on Ranges 37, 38, and 39, he stage of water would admit, and a screened dike 400 feet long driven head of the tow-head for the purpose of attempting to shield it against the hich set directly against it. At this time the water stood so high that brush ent could not be had. A small quantity of brush remained on hand, and sed in constructing a mat 130 feet wide in rear of dike 37, to prevent a y cutting through the chute.

the season the head and upper flanks of the tow-head were mattressed, but rise went over the top of the island and washed it in two behind the mat- h remains as an obstruction in the channel. The dikes on Ranges 37, 38, ave been completed, except narrow channels for communication through

[illegible] a heavy dike begun on Range 36. The details of these dikes are show[n on] the accompanying maps.

The works at Upper Duncansby have now, through the changes at Pilcher's P[oint], become too far advanced, and that system is seriously threatened with destruc[tion]. A line further retired must be defined by the river itself. It does not seem to b[e] possible to hold the present upper tow-head, but rather to dike out from the Missi[ssippi] shore to determine the continued filling of the chute below and allow the ri[ver to] make a more easy curve by cutting down further the upper tow-head. The [chute] under the influence of the works above is very fast filling up.

4.—MAYERSVILLE SYSTEM.

The contraction works of this system as designed include a main dike and a[t] three cross-dikes on Cottonwood Bar to prevent the river cutting through nea[r] Louisiana shore and to hold the water in the bend of Island 93, a dike acro[ss] head of the chute at Island 93, and a strong dike across the chute at Mayer[sville] Landing. Of these works the dike across the head of the chute was constructed [prior] to the last annual report, and the dike at Mayersville built at high water last [sea]son. The first of these works consists of an open dike, three rows of braced [piles] reaching to about the 17-foot stage and mattressed at foot; the cross-dike consi[sts of] two rows of braced piles reaching nearly to the 30-foot stage. It is expected [that] this last dike will cause the filling of the chute by drift-wood lodging against i[t. It is] not yet mattressed at foot, but this will, if practicable, be completed before [low] water. The dike at the head of the chute passed the flood without injury and c[aused] a very appreciable fill behind it, the chute going dry at low water both at hea[d and] foot. The dikes to be constructed on Cottonwood Bar gain in importance as the [cav]ing at the head of the Duncansby system moves downward. A channel through [the] bar may endanger the dikes on the Baleshed Bar below.

5.—REVETMENT OF ISLAND 93.

At the date of the last annual report of the Commission, there had been constr[ucted] at the head of this island 1,719 linear feet of under-water mattress. After that, [until] interrupted by the high water of February, 1883, the mattress-work was p[ushed] vigorously, until it extended along the face of the island about one and a half [miles]. In December, also, one of the graders was put at work, and the brush-work o[f the] upper bank revetment was followed down 1,700 feet, and partially weighted [with] sand-bags and stone. As the holding of the face of this tow-head is essential t[o the] completion of the project below, the mat-work was pressed, but due to a lack of [means] for sinking mats and covering the upper bank, the work was caught by the flo[od in] [an in]complete condition. Some [illegible] feet of the upper bank revetment was lost, an[d the] [illegible] washed back from 10 feet to 300 feet back of the mat [illegible] the bottom of the river. The work is being done over again. [illegible] threatened in consequence of lack of material and [illegible]. On the face of this island both of the hydraulic gr[aders] [illegible] advantage, the average cost of excavation being for th[e] [illegible] yard, including fuel, oil, and repairs.

6.—BALESHED CONTRACTION WORKS.

[illegible] Stack Island extends the Lake Providence Reach proper, a st[retch] [illegible] have been built on the Mississippi side the Baleshe[d] [illegible]. These works are designed to close the chute behind Baleshed Bar [illegible] the head of Stack Island Chute to aid in closing also [illegible].

[illegible] longitudinal dike from the main Mississippi shore [illegible] the crest of Baleshed Bar, to the head of Stack Island, [illegible] and partly completed.

[illegible] dike at the head of Baleshed Chute and four (pa[rtial]) [illegible] had been driven during the low water of 1882, and are rep[orted] [illegible]. All the dikes of 1882 were low, reaching t[o] [illegible]. In February, 1883, work was resumed at [illegible] and has been prosecuted continuously to date. At high [water] [illegible] to pass behind Baleshed Bar was exhi[bited] [illegible]. In resuming work at high water, to preven[t] [illegible] was experienced from drift, and many of the [illegible]. A [illegible], however, was at last effected, a[nd] [illegible] feet of pile dike had been constructed and a [illegible].

Of the cross-dikes, six extend from the main dike across to the Mississippi shore, and six are still incomplete, not having been extended across the chute on account of deep water.

At the head of the system the main dike is built of three rows of braced piles, but on the highest part of the bar it is only of two rows. The cross-dikes at head are of three, four, and five rows, the better to withstand drift, and are protected at foot with thick foot-mats. The high dikes all reach to or above the 25-foot stage, and for 6 feet above the present bar surface are now being closely wattled to secure deposits of mud for the sustenance of willows, which have already begun to make their appearance.

On the decline in the river the deposits behind the long dikes were cut in channels by the water seeking the deep chute behind Baleshed Bar; in several places at head, and here also, the main dike is being closely wattled to prevent this action.

In front of the main dike a mattress, ranging in width from 100 feet at head to 60 feet at foot, has been laid to prevent longitudinal scour, and in places where the water falls through the dike into Baleshed Chute, grillage-mats have also been placed.

Along this system the local effects of main and cross-dikes can be well studied, as well as the influence of drift as an enemy or as an aid to these constructions, the cross-dikes driven at high water having caught much of it. This will be spoken of hereafter in this report.

The effect of the dikes of this Baleshed system has been all that could be expected. Although open, *i. e.*, not wattled or curtained, they have caused a great fill behind them, have extended the bar both at head and foot, and thrown the current well over to the Louisiana shore, opposite the head of Stack Island, and have perhaps rendered the permanent closure of that chute, which is now 83 feet deep at low water, a possibility in the future, the main channel of the river having already been diverted or deflected from that chute by these works, aided by the dikes reaching from the foot of Baleshed Bar to the head of Stack Island, and the short dikes on the opposite side of the river at Elton.

The proposed channel at the head of Stack Island was projected through the crest of Hopewell Bar, and the change here has been a remarkable one. The Stack Island Chute next the Mississippi shore was 80 feet deep at low water. The Elton Chute, along the opposite or Louisiana shore, was also deep, exceeding 30 feet at low water, and the Hopewell Bar filled up the greater part of the main projected channel-way.

An open dike was built above the head of Stack Island on the crest of the crossing or weir, and a series of six short spur-dikes across the head of the Elton Chute. At high water these dikes induced a deposit, as shown on the map of the April survey herewith, and the main river cut its channel to the right of the island, as projected, removing immense deposits of sand. For some time this main channel was more shoal than either of the chutes next shore, or the river ran in a trough excavated through a mound in the middle of the river. The tendency is to cut across the narrow ridge at the head of Stack Island, and to fall back into the deep trough behind that island.

The dike work so far built here, at Stack Island and Elton, is insignificant in character and must be very materially extended and made both stronger and less permeable in order to permanently keep the river out of the chute.

Although the works have been nearly altogether open pile-dikes, the effects on the reach have been very marked in deepening the channel.

During the last low water there was a good channel not less than 15 feet in depth throughout the reach, and navigation was without a hindrance anywhere.

There are attached hereto tables giving all the work done on the reach, prepared by Assistant Engineer Hider, who has also given a detailed description of all constructions used.

The machines and appliances used on the work have been the same as heretofore, with the exception of an appliance for holding the head of a mattress in swift water during construction, and until it is safely sunk to the bottom of the river. This consists of a strong truss floating at the head of the mattress, to the lower chord of which the mattress is attached every 8 feet by rings and tripping-hooks, the latter of which can all be tripped simultaneously by a rod attached to a lever at the shore end of the truss and the truss released from the mat. A modification of the hurdle-mattress has also been found necessary in the deep and swift currents encountered. This modification consists in running alongside the poles on which the mattress is woven continuous lines of iron rods, 25 feet in length, connected by lap-rings and clevises, the rods ranging in diameter from ⅜ to ⅝ of an inch. Drawings and descriptions of this mattress and mattress-head are herewith. They have been used successfully at Pilcher's Point, as may be seen from Assistant Engineer Turtle's report herewith.

The detachable mattress-head is a great assistance in sinking, without danger, the ends of continuous mats in swift currents.

Modifications have also been found necessary in the pile-dikes, which are now provided with thick foot-mats, and are built of three rows, sometimes of five rows, in all

exposed places. In three-row cross-dikes the wattling is placed on the middle row, or along the middle line of the foot-mat. In five-row dikes it is proposed to wattle the second and fourth rows. The latter construction is proposed for closing chutes, the two-wattled rows representing two cross-dikes with a short pool between them, gaining the advantage of wider foot-mats and stronger anchorage over two cross-dikes of less width farther apart.

The vertical close wattling has been adopted instead of inclined mats, or curtains, as first used, on account of the greater cheapness of the construction, as less material is required. An eddy will be produced under the lip or crest of the wattling when the water passes over the wattling. At the first stages of the fill below the dikes there will be a trough immediately below the wattling, due to this eddy, but after the fill above and below reaches the level of the top of the wattled portion of the dike these troughs will evidently fill up even with the top of the general fill and the wattling be covered.

All the results accomplished on the Lake Providence Reach have been by open dikes, mostly without either screens or foot-mats. It is certain that the currents can be reduced in velocity by piles alone until they are too gentle to scour much at the foot of the dikes, and that piles alone offer sufficient obstruction to cause great fills behind them. When the dikes are mattressed at the foot there is danger that if the work is not a success the mats will remain a permanent obstruction to navigation.

It seems that it is better to secure the fill, if possible, by means which cannot by any possibility be damaging if they fail, and afterwards, with an expenditure of much less material than necessary to mattress and wattle or curtain all the dikes, to mattress only the proper parts of the new banks secured, or else in the first construction to restrict the brush work to important parts of the dikes only. The necessity for mattressing and wattling pile dikes causes great delay to the revetment of banks; causes the time, labor, material, and means to be expended to protect cottonwood piles that can last but two years at best, when our efforts would be more profitably directed to the bank work, which is more of a finality. It is my impression that no pile work is worth the extra expense of mattressing, except strong dikes placed in chutes to close them, and the main lines along the proposed new banks. Those for closing chutes should be built of cypress piles, well braced to stand any pressure that may be brought against them, heavily mattressed at foot against scour, and wattled or thickly curtained to form permeable or submergible dams.

DRIFT-WOOD.

During the early part of the rise last February, fields of drift were brought down by the flood and lodged against our piling. Most of this, on the further rise, was released and floated past, but on two of the cross-dikes on Baleshed Bar there were great accumulations. These dikes were only of two rows of piles, not provided with mats at bottom, and but insecurely braced. They were strengthened by additional rows of piles driven behind them, and the drift held by them. At first small parts of the dikes at the ends were broken away, but it has not been ascertained whether by natural scour around the outer ends of the spur dikes, or by impact of drift. The great mass of the drift accumulation was retained, and still remains above these dikes. Afterwards drift in smaller quantities lodged against the high cross-dikes in Baleshed Chute, and in one or two cases gaps were washed out in the dikes, due to its influence.

In all cases where *considerable* quantities of drift accumulated at high water there has not only not been any scour under the drift, but there has been a considerable fill, both under the drift and below it.

The action of the drift on the currents and dikes seems to be this: If in small quantities, extending a few feet only above the dike, and of moderate depth, it acts as a barrier with an aperture underneath; the head of water is increased by the barrier and the current under it directed against the bottom at the foot of the piles, which, under these circumstances, if not protected, are likely to scour out. When the accumulation gets larger the friction of the drift and bottom is more than sufficient to kill the current due to the hydrostatic head formed by the resistance of the drift to the current, flowing down upon it, and the water flowing under the drift heap runs with less velocity than before, and deposits sediment. The main body of the water then flows off along the sides of the drift obstruction, and endangers the piles on the flanks of the accumulations. A *small quantity* of drift, then, is dangerous; a *large quantity* is a help and an aid. If pile dikes are then built sufficiently strong to withstand the impact of the drift, and protected at foot sufficiently to stand the scour consequent upon the first small accumulations, this material may be made a very important part of our resources in filling up chutes and building bars.

I do not know of any case on the Providence Reach where piling yielded to *pressure*

of drift, but there were cases where dikes were broken by the force of impact, and others by scour, caused by small drift accumulations. There are other cases where the flotation of drift is supposed to have pulled piles out as the water rose.

FINANCIAL STATEMENT.

Lake Providence Reach.

Balance from previous appropriations	$13,573 85	
Allotment under act of August, 1882	650,000 00	
New Madrid allotment (transferred)	187,500 00	
Additional allotment from unallotted reserve	112,500 00	
		$963,573 85
Expended by Captain Marshall, from July 1, 1882, to December 1, 1882:		
Plant and tools	$23,068 48	
Piles, coal, &c	3,873 15	
Services	46,061 80	
Tow-boat service	5,492 03	
Subsistence	6,968 33	
Miscellaneous	1,611 44	
Total	87,075 23	
Expended by Captain Marshall, from December 1, 1882, to November 1, 1883:		
Plant and tools	$63,766 26	
Brush, piles, &c	77,516 84	
Services: Construction	152,050 43	
Surveys	7,222 07	
Office and headquarters	10,433 64	
Tow-boats (including charter)	17,454 11	
Snag-boat	625 32	
Medical attendance (including drugs)	1,626 06	
Subsistence	22,774 61	
Miscellaneous (including transportation, traveling expenses, &c)	7,170 02	
Total	360,639 36	
Expended by Captain Marshall:		
From July 1, 1882 to December 1, 1882	$87,075 23	
From December 1, 1882, to November 1, 1883	360,639 36	
	447,714 59	
Expended by Captain Sears	359,531 33	
Total expenditures		807,245 92
Balance available November 1, 1883		156,327 93
Balance in Treasury		137,000 00
Balance in hands of Captain Sears		4,700 78
Balance in hands of Captain Marshall		14,627 15
		156,327 93

The followi[...] penditures were made by the executive officer, Mississippi River Commission, i[...] ating property, &c., for use on Lake Providence Reach:

Description.	Number.	First cost, each.	Total cost.	Date of payment.	Marks and numbers.
Barges	11	$2,000 00	$22,000 00	Dec., 1882, to Mar., 1883	77, '8, '9, 80, '1, '2, '3, '4, '5, '6, '7.
	8	2,400 00	19,200 00	Jan. to Mar., 1883	88, 91, 154, '5, '6, '7, '8, '9.
	2	1,960 00	3,920 00	June, 1883	59, 60.
	1	1,300 00	1,300 00	Mar., 1883	194.
	4	2,000 00	8,000 00	Not known	135, '6, '7, '8.
Total	26	....	54,420 00		
Mattress-boats	2	6,900 00	13,800 00	June to Aug., 1883	30, 31.
Steam tow-boat	1	17,404 00	17,404 00	Jan., 1883	De Pauw, now Vidalia.
Quarter-boats	4	4,000 00	16,000 00	Apr., 1883	21, '2, '3, '4.
Skiffs with oars	5	20 00	100 00	Jan., 1883	
	10	20 25	202 50	July, 1883	
	8	25 50	204 00	Aug., 1883	
Total	23	....	506 50		
Electric light and outfit	1	938 50	938 50	June, 1883	
Anchors	....	....	365 58	Mar. to Apr., 1883	
Outfit of quarters, boats and other plant	....	....	3,920 10	Jan. to June, 1883	
Total	....	....	107,354 68		

Barges Nos. 135, 136, 137, 138, in use on Lake Providence Reach, were paid for out of Memphis allotment; four, at $2,000=$8,000.

This list does not include plant bought for general service out of Lake Providence allotment.

REVETMENT AT DELTA POINT.

This work during the last year was carried on under the immediate direction of Assistant Engineer H. St. L. Coppée, and was a continuation of the work begun in 1878, under the supervision of Maj. W. H. H. Benyaurd, Corps of Engineers, in accordance with the recommendation of the Board of Engineers upon the Restoration of the Harbor of Vicksburg, published in the report of the Chief of Engineers for 1878.

The report of Mr. Coppée herewith is full and details at length the work done.

A description of the methods employed was given by Mr. Coppée in the last annual report of the Commission, at which time about 1,100 feet of the work was completed. From the date of that report (December 1, 1882) work progressed continuously until February 10, 1883, when the allotment had been expended. The plant was then transferred to Wilson's Point, La.

The work during the past year was carried on in the same manner as described in the former report, with the exception that the piles through the shore edges of the mats were omitted, in order that if high water should find the work incomplete, continuous mats might be sunk without interruption, overlapping the low-water mattress, and with the further exception that a mud flat some 250 feet wide, below the old bank, was not revetted above the 12-foot stage; also the upper bank revetment of the last 625 feet consisted of a woven hurdle-mat sunk at high water, reaching to the 32-foot stage, instead of the usual upper bank revetment which could not then be placed.

The work was carried several hundreds of feet below the head of the sand-bar at the point at low water.

The low water just passed revealed that the work done under the Commission stood intact, but that the mud flat mentioned above should be covered with brush and stone to prevent a possible eddy-cut around the revetted old bank.

A small portion of the dike built in 1879 at the projecting point itself has fallen in, due, probably, to the rotting away of the thick brush mats of which the dike was principally built. In all, about 500 linear feet of brush and stone patch-work should be done to secure the work against another flood. In all, about 4,000 feet of revetment measured along the bank was laid, costing, including additional quarters on shore, one quarter-boat, and the redecking of one barge, towing, superintendence, tools transferred to Wilson's Point, La., &c., $75,762.49, or $18.75 per linear foot. Mr. Coppée estimates the actual cost of labor, subsistence, towing, and material as $13.37 per linear foot, as the actual cost of the work done.

FINANCIAL STATEMENT.

oved June 18, 1878		$84,000 00
oved March 3, 1879		50,000 00
oved June 14, 1880		20,000 00
oved March 3, 1881		75,000 00
its from appropriation for improving Mississippi River, Au- 82		50,000 00
		279,000 00
rior to December 1, 1882		231,242 17
ilable December 1, 1882		47,757 83
ince December 1, 1882:		
nt and tools	$1,335 39	
vices	22,781 45	
sistence	6,318 46	
ne and coal	12,260 92	
rter of tow-boats, &c	3,408 37	
ce supplies	257 57	
aneous (including traveling expenses, transporta- quarters, mule hire, &c)	1,388 03	
		47,750 19
ilable November 1, 1883		7 64

DREDGING IN VICKSBURG HARBOR.

allotment of $100,000 made by the Commission from the general appro- improving Mississippi River, and the project adopted by them September, ere solicited for dredging, and received and opened just before the date nnual report. An abstract of the bids received was published in the last e Commission.

ct for this work was to excavate a basin 300 feet wide, 1,700 feet long in elevator; a canal 150 feet wide from this basin to deep water in the lake, o open the west entrance to the lake. The dredging to be done to the Vicksburg gauge.

t responsible bidder for this work was Mr. Rittenhouse Moore, of Mobile, nts. The next lowest, S. N. Kimball, of Mobile, Ala., at 18¾. The third, ., of Baltimore, Md., at 19 cents per cubic yard. Of the three, Moore he could not begin work until February 10; Kimball was not provided and Fobes & Co. expressed their ability to complete the work by June 30. sible success of the entire project for the year's work depended upon the th which the work could be done, and it was especially necessary that it mpleted before the decline of the water that could be expected in July, mmended that the work should be divided; one-half to Moore at his bid, er half to Kimball or Fobes & Co., at their prices. The entire contract d to Rittenhouse Moore, of Mobile, Ala., the lowest responsible bidder, able to begin at the time required, prosecute the work with the vigor re- r the specifications, or complete it within the time specified. The work ractor was not begun until April 5, 1883, and was prosecuted, with many il September 18, 1883, when, on account of the rapid decline of the river, g was necessarily suspended, less than one-half the required work having ned.

ns to be given hereafter in this report, the contract was then allowed to 85 cubic yards having been removed.

he period covered by the dredging operations, the basin was excavated zero of the gauge for a width of 160 feet, and four additional cuts; or 160 down to the +5′ plane, 80 feet in width of the canal was excavated to ne, and an attempt was made to excavate the West Pass, which since the water had filled until the depth of cut required was about 17 feet. The ed for want of proper facilities for removing the material excavated, which sand, and the work there was ordered abandoned by the construction com- ssippi River Commission, August 22, 1883.

ence of the failure of the dredging operations at West Pass, and the in- ndition of the basin, the wharf-boat was removed from the upper landing , August 7, 1883, when the river stood at 23.7 feet on the Vicksburg gauge, er boats were excluded from the harbor a few days later, or after the d the 20-foot stage at Vicksburg.

[illegible] of the water below the edges of the excavated area extensive slough-[illegible] inwards of the mud deposit composing its side took place, and on [illegible]i-fluidity, or plasticity, the weight of the banks themselves caused an [illegible] bottom until the slopes reached the inclination of $\frac{1}{8}$, $\frac{1}{10}$, and in places [illegible]al was greatest in the deepest part of the excavation, on account of [illegible] high deposit along the Vicksburg front, which sunk down vertically [illegible] The upheaval here amounted to as much as 8 feet. This material [illegible] [illegible]ved to the zero plane for a width of 80 feet by the dredge prior to [illegible]

[illegible] the excavated area are now quite regular, with nearly uniform slopes [illegible]cal to eight horizontal.

The [illegible]ux of water through the narrow and shallow cut made by the dredge at the West [illegible] was sufficient to keep the sand-bar cut down as the river fell, and small boats [illegible]gain to make their appearance in the harbor on the first rise of three and a [illegible] At the 12-foot stage steamers drawing 5 feet of water now land at the wh[illegible]nding in front of the city, turn in the basin, and go out through the canal and cut [illegible] the West Pass. Larger boats, it is expected, will make their appearance at a lower stage of water than for several years. To this extent the dredging has been [illegible]ccess, and the benefits so far secured will probably more than repay the expendi[illegible] [illegible]ll up at once with sand on the first rise. The rapid [illegible] of [illegible]ning river, as well as the unexpectedly flat slopes a[illegible] by [illegible]d area, making it evident that the cost of the prese[illegible]ject [illegible]lly greater than contemplated, and temporary adva[illegible] from dred[illegible]resent low-water season being doubtful, it was recom[illegible]ded to the [illegible]t the present contract for dredging be allowed to expire on the date [illegible]n and the work abandoned; which recommendation was approved and [illegible]nate the contract.

Early in September a sur[illegible]ganized by Assistant Engineer Coppée, and in accordance with the [illegible] Commission passed in June, 1883, a low-water survey of the area [illegible]posed works was made. The results of the survey [illegible] Mr. [illegible]report herewith.

The main [illegible]

There ha[illegible]ithin [illegible]ered by the proposed canal and basin ranging from five [illegible] twent[illegible]h, the greatest fill being near the river. This fill within the limits of t[illegible]anal amounts to 1,255,486.4 cubic yards, or the amount to be removed ha[illegible]sed that much by the cause mentioned in the past year.

The river has been thrown over against the bar at the West Entrance, and has cut down a deep tongue-shaped trough through the center of last year's bar, cut down its crest near the Mississippi shore, and piled up a barrier with a nearly horizontal [illegible] across the southwest end of the lake. The tendency of the river is to cut away Young's Point and the sand-bar above Delta, and make its bend further in towards Vicksburg, lengthening its radius of curvature. This change will necessitate more extensive revetment of banks above Delta to protect the work already done. The [illegible] of the change will not probably materially shorten the distance from Vicksburg to deep water for many years.

The increased eddy current around De Soto Island, and the consequent increased [illegible] in the harbor of Vicksburg, results directly from the changes at Young's Point. This current will evidently increase as the water is thrown further in towards Vicksburg, until the access of water to the lake is entirely cut off by the deposit. The river is now rapidly developing its new high-water shore-line across the ends of the lake.

Soundings made in May revealed at that time an average fill of only about one foot on the Vicksburg front, so that the great fill, shown by Coppée's recent survey, took place [illegible] on the decline of the water after June 1. This, if it always happens, is a very important fact in connection with further dredging operations in the harbor. [illegible] the bulk of the annual fill must be removed each year after June 1, or on the decline of the river, which is always rapid, or during low water, the project to maintain [illegible] navigation by annual dredging would seem impracticable, for the [illegible] in that case does not take place before its removal is necessary, nor can it be removed [illegible] before the rise in the river in the late fall restores navigation. The [illegible] seems practicable by dredging alone under these conditions is to prolong the season of navigation, and to hasten the return each year of the steamers to the [illegible]

[illegible] therefore be necessary to introduce some scouring force, as the Yazoo River, [illegible] the third and final step proposed by the Board of Engineers of 1877, in [illegible] current outwards may be had to prevent ingress of mud and to keep [illegible] [illegible]

[illegible] be done by annual appropriations these appropriations must be sufficient to allow the annual fill during the progress of the work to be removed—[illegible] will cost over $[illegible] per annum—and also at the same time, [illegible]

avoid this recurring expense, to make rapid progress on the main work itself i. e., the excavation of the channel for the Yazoo from Old River to Centennial Lake, and from Centennial Lake to deep water in the river.

In the estimates prepared by the Board of Engineers in 1877 the cost of the diversion of the Yazoo via the dead end of Old River is placed at $1,600,000. The removal of the deposit from the line of the canal is estimated (now) to cost $766,000, with a probable annual expenditure to maintain an open canal of about $200,000, or say, if the work be done simultaneously and at once, $2,600,000. The assessed valuation of the city of Vicksburg, real estate only, was for last year (1882) $2,459,000. The present steamboat landing is about 4,800 feet below the elevator. Annual value of the commerce of the city, about $10,500,000.

There is still another scheme which finds favor in Vicksburg—as does, indeed, any plan for restoring its water front—and it is this, that since the river has now determined that Vicksburg is on the dead end of the cut off, and the expense of damming of the Mississippi mud at that end is small compared with the expense of dredging at the deposit, let the Yazoo be diverted and allowed to go out at the West Pass and a boat passage be dredged from the city front to the deep water in the then live end of the lake. This would reduce the probable expense about one-third and allow the diversion of the Yazoo to be made with advantage to the city prior to excavating the necessary basin and canal from deep water in the lake along the city front to deep water in the river, or it would make the two works independent of each other. The disadvantages of placing the town at the dead end of the cut-off are evident, but the scheme is advantageous from the above considerations and from the further fact that it is not opposed to the canal for the Yazoo ultimately along the city front, the west entrance requiring only to be stopped for one low-water season, and the canal in front of the city to be prosecuted to completion, to effect this end as proposed.

If this scheme were executed it would be advantageous to put all dredged material along the crest of the mud-bar and across the line of the proposed canal in front of the town, near Ryan's mill, to shut off ingress of muddy water, where it now requires a dam from 16 to 24 feet in height to entirely close that line at ordinary high water. The west arm of the lake, formed by the cut-off, is gradually shoaling behind the bar, and here also there might be considerable dredging required before the deposit is of sufficient depth to allow a defined channel for the diverted river, or rather before the new banks of the Yazoo are formed by the contraction due to the slow deposit.

Every scheme, however, having in view the diversion of the Yazoo or the execution of a canal, involves annual dredging to maintain the proposed works. At the present mouth of the Yazoo this past low water there was only four feet of water. Boats drawing three feet struck and encountered difficulty, and it is not to be presumed that it will be deeper at the proposed mouth.

The training of the Mississippi by deflecting or silting dikes and revetments above De Soto Point and at Young's Point is also proposed for the purpose of bringing the river farther in towards the town, but the cost and result of such works are still more problematical and less adapted to close estimates; the works would be tentative and costly. It is practicable, however, to maintain the river where it is, at least for many years, and it is to this work that it seems advisable to direct our efforts until doubt as to the sufficiency of the works for that end is removed.

With reference to the further prosecution of work here, then, the following propositions have been made, and are given in the order of cost:

1st. Abandon the "restoration" of Vicksburg Harbor and maintain the low-water landing at Kleinston, 4,800 feet below. This requires constant watching and care of De Soto Point, and an extension of the revetment, after the bar above has cut away as far up stream as the head of the caving in this bend. All other projects also require this.

2d. Scrape or dredge the bar at West Entrance sufficiently to determine the line of cutting down due to the efflux of water during the falling stages, to allow an earlier return of vessels to the Vicksburg front. This will require also dredging in the basin and canal dredged this year to a greater or less extent, as it fills up. No estimate can be made, but it will probably not be less than $30,000 per annum after the first year. Temporary.

3d. Divert the Yazoo into Centennial Lake, and allow its current to flow out at West Pass, and keep present canal and basin dredged. Approximate cost, $1,850,000, first cost, and annual dredging in canal, basin, and West Pass to maintain it. If the high-water discharge of the Yazoo must be controlled, this estimate will be increased. This condition would make the scheme impracticable.

4th. Divert the Yazoo, close the West Pass, and dredge canal and basin in front of the city. Estimated at $2,600,000, with annual dredging at mouth of canal. Same remark concerning high-water control of the Yazoo.

The condition that the navigation of the Yazoo shall not be interfered with by the works would introduce additional difficulties in the execution of any scheme involving a diversion of the Yazoo.

[illegible] work for the permanent restoration of the harbor of Vicksburg [illegible] with the value of the general commercial interests involved [illegible] any recommendation in the matter, but the scheme for leaving [illegible] of the lake seems the least expensive way of affording [illegible] and low-water stages. The filling in rear of the bar at the [illegible] render it so wide and of such material that the outflow of water [illegible] work noted this year. The cutting out there during the past low water [illegible] the fact that the bar was very narrow and of pure sand, without any cohesion [illegible] between its particles. When mixed with mud, like the material in rear of the [illegible] cutting will be very much reduced. A widening of the crest of the bar will also [illegible] the same effect, for the increased friction may probably even convert the bar into [illegible] before the force of the outflow on the decline can roll the sand out of the way or cut through the mud deposits in rear.

FINANCIAL STATEMENT.

Amount allotted for dredging in Vicksburg Harbor		$100,000 00
Expended—		
For contractor's [illegible]	$38,119 92	
For services	5,498 22	
For advertising	305 34	
For office supplies	300 46	
For miscellaneous	498 56	
Total expenditures		44,522 4[illegible]
Balance available November 1, 1883		55,477 [illegible]

CONSTRUCTION AND REPAIR OF THE LEVEES OF THE MISSISSIPPI RIVER, TENSAS AND YAZOO FRONTS.

A complete list of the levee contracts awarded by the War Department, in accordance with the recommendations of the Board of Engineers that convened at Memphis, Tenn., September 4, 1882, was published in the annual report of the Mississippi River Commission for 1882.

As the contracts were dated October 3 and October 23, 1882, the contractors had barely commenced operations at the date of the last annual report of the commission, and for that reason the entire work done under these contracts, and under the last appropriation, is reported in this report.

In the latter part of November and in December [illegible] forces were placed upon the various works by the contractors, [illegible] considering the short time during which work could be [illegible] prosecuted their works, until interrupted by the flood of February and March, 188[illegible].

The great bulk of the earthwork had at that time been put in place, but the following-named levees were caught in an incomplete [illegible] were encountered.

On the Tensas front, in Arkansas, the Panther Forest levee had been completed except the sodding, and a large part of this also was in place [illegible] pressure during a rain-storm on February 22, and during the flood [illegible] about 8[illegible] cubic yards, washed away. The amount of [illegible] was insufficient to build it of sufficient height [illegible] the pressure of the water upon the material composing it. This was a very [illegible] in the river, which water, in its unsettled state, soon converted [illegible] paste. The levee began sloughing at rear and was speedily broken through. The [illegible] percentage [illegible] has not been paid to the contractor. The levee would [illegible] have been carried away whether the [illegible] sodding [illegible] at considerable intervals, had been done or not. The [illegible] immediately behind the levee, who took the contract to insure its timely completion.

In Louisiana, on the Tensas front, the "Wilson to Raleigh" levee, the largest and most important work of the kind in the district, was caught by the flood in an incomplete state. Of the 4 miles of the line nearly 2 miles had been [illegible]. The work had been purposely prosecuted so as to [illegible] incomplete portion of the levee behind a remnant of the old levee some 1,2[illegible] to 1,5[illegible] feet nearer the river, in order that if floods threatened wings or flanks might be thrown back to this old levee as a curtain. Immediately upon the [illegible] of the great flood in the Ohio River an order was issued to the contractors to hasten the construction of these works of protection, which required some 35,000 cubic yards of earth to complete. The upper wing was completed

preserve the heavy buckshot levee, closing the "Alsatia" crevasse; but the ing the Edgwood and Illawara crevasses, was carried away in a wind and rain ing the night, and there resulted to the contractor a loss of about 32,600 cubic arthwork. The river having determined a new channel through the chute of the wings, proposed last winter as protection works, are now made parts of line, the old levee in front being enlarged and used also as part of the main

to Milliken's bend" levee, Louisiana, another large and important work, was incomplete condition, and the saving it was rendered still more difficult by at water collected behind the levee, which, with the river pressing in front of a supply of material with which to raise it. Barges were sent down from the Wilson's Point, and by strenuous efforts the top of the levee was kept above material transported from a distance, and the entire work saved.

"Delta to Bedford's" lévee, six miles in length, a gap of 1,100 feet was un- Backwater from the Diamond Island crevasses shut off access to it, and the an running through low places in the banks in front. Here a line of protec- , nearly three miles long, along the edge of the river bank was built, which, the situation allowed, was reduced in length to about one-half by a cross-levee in work, built by hired labor. This long line several times gave way in t the gaps were in each case promptly closed, and the work saved.

Yazoo front, in Mississippi, the flood found the levees in such condition that entirely safe, except the Longwood, Skipwith, and Elleslie levees, at each of tection levees were built.

Elleslie gave way from a storm dashing waves against it, and the water broke e incomplete main line, flooding several plantations and washing out 2,600 cubic rth from the main levee. This break was more advantageous than otherwise to d lands. The banks are high, and the water on the first decline of the river was ided by a second protection levee along the site of the first.

ed hereto are reports of Assistant Engineer H. D. Garden, in charge of the the Tensas front in Louisiana, and of Assistant Engineer George M. Helm, in the Yazoo levees in Mississippi, which give in condensed form information g the levees built in the district.

latter gentleman has been chief engineer of the Mississippi Levee Board for the years, and has had much experience in levee construction, he was requested to s report, for the information of the Commission, a statement of the work done ree district authorities during the past eighteen months, and also to submit the ties, as shown by his experience, in stopping crevasses, building heavy levees ble foundations, and revetting the ends of breaks to prevent enlargement. tlemen submit estimates for raising the levees in their charge to 3 feet above r mark of 1882.

re also submitted with this report tables showing earthwork built in the dis- March 1, 1883, or in four months prior to the flood, and the condition of the levee ler the various contracts November 1, 1883, the date of this report. From this le it appears that there has been built in all, including the small amounts re- last annual report:

	Cubic yards.
ont, Arkansas	243,428.0
ont, Louisiana	1,001,734.0
nt, Mississippi	1,193,281.1
tal	2,438,443.1

there remains to be done—

	Cubic yards.
ensas front in Louisiana	99,381.6
'azoo front	14,627.0
	114,008.6

pected that work will be completed and contracts closed by December 1, 1883. ases the grades of the levees have been restricted to the grades of the old levees, Wilton to Raleigh where the bank was exceptionally low, and the levee of very onstruction, from the nature of the material.

r break here would make it still more difficult and costly to rebuild the levee, d allow enormous quantities of water to escape from the channel, the ill effects on navigation are now seen just below the present crevasse, at Foster's.

se reasons, the grade as established for this levee was placed at about 18 inches n that of the levees immediately above and below, which were on high ground, evee across the sandy part of the line built of increased dimensions.

FINANCIAL STATEMENT.

Tensas front.

To amount allotted			$32[illegible]
To amount transferred from Yazoo front			2[illegible]
To amount redeposited on account of error in voucher 45			[illegible]
Total			348[illegible]
Expended prior to December 1, 1882:			
Contractor's estimates	$28,888 06		
Services	2,616 05		
Instruments	1,319 35		
Subsistence	177 93		
Miscellaneous	637 20		
		$33,638 59	
Expended from December 1, 1882, to November 1, 1883:			
Contractor's estimates	$239,531 20		
Services	10,372 11		
Services on protection levees	4,662 79		
Instruments	282 75		
Subsistence	135 69		
Office supplies	357 42		
Miscellaneous (including bags used on protection levees)	2,176 94		
		257,518 90	
Total expenditures			291,[illegible]
Balance available November 1, 1883			57,[illegible]

Yazoo front.

To amount allotted			$35[illegible]
By amount transferred to Tensas front			2[illegible]
Balance			3[illegible]
Expended prior to December 1, 1882:			
Contractor's estimates	$28,435 49		
Services	1,511 00		
Miscellaneous	112 61		
		$30,059 10	
Expended from December 1, 1882, to November 1, 1883:			
Contractor's estimates	$266,749 89		
Services	12,504 33		
Services on protection levees	1,082 73		
Office supplies	304 50		
Instruments	170 60		
Miscellaneous (including bags used on protection levees)	2,965 17		
		283,[illegible]	
Total expenditures			[illegible] 22
Balance available November 1, 1883			[illegible]

nount of earthwork constructed on levees, third district, before the d amount constructed since then to November 1, 1883.

	Total amount in levee. Approx.	Amount constructed March 1, 1883, date of expiration of contracts.	Amount constructed since March 1, 1883.	Amount yet to be constructed.
:	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.
....	243,903.3	182,739.0	61,164.3	....
....	....	20,000.0	....	....
....	39,156.9	39,156.9	....	....
ele........	90,002.2	90,002.2	....	....
....	199,059.2	156,032.6	43,026.6	....
....	41,287.7	41,287.7	....	....
....	* 387,941.8	225,495.0	63,065.2	99,381.6
....	....	16,572.0	....	....
....	61,162.9	61,162.9	....	....
....	....	2,029.6	....	....
....	80,246.0	80,246.0	....	....
....	163,182.0	163,182.0	....	....
	1,305,942.0	1,077,905.9	167,256.1	99,381.6
'ST.				
....	49,357.0	49,357.0	....	....
....	67,299.1	67,299.1	....	....
....	133,500.0	104,627.9	28,872.1	....
....	....	2,796.0	....	....
....	71,660.0	63,067.0	8,593.0	....
....	....	3,500.0	....	....
....	75,891.0	60,041.0	15,850.0	....
....	....	15,978.0	....	....
....	58,631.0	31,017.0	20,270.0	7,344.0
....	156,213.0	155,149.0	1,064.0	....
nds........	103,298.0	95,148.0	867.0	7,283.0
....	50,714.0	50,112.0	602.0	....
....	22,882.0	22,882.0	....	....
....	150,538.0	139,797.0	10,741.0	....
....	66,836.0	66,836.0	....	....
....	27,152.0	27,152.0	....	....
....	151,663.0	151,663.0	....	....
	1,185,634.1	1,106,422.0	86,859.1	14,627.0

31,552 cubic yards, which was washed away during flood of 1883. It has Second Comptroller of the Treasury whether this quantity will have to tractors, at their expense, or paid for by the Government.
f the levee, the amount of 13,302.1 cubic yards already paid for was of levee.
levee when completed will be 343,087.7 cubic yards.

LEVEE SURVEYS THIRD DISTRICT.

l,000 made by the Mississippi River Commission at their meet-arty was organized September 20, 1883, by Assistant Engineer y and location of levees in Arkansas from the high land on 1, 7 miles back from the river and about 16 miles above ana State line.

ey was completed November 1, 18 stant Star-culation of volumes and in plottin and neces-where broken.

nest of the president of the co ptes of the rkansas City have been reduce from Amos hese ... show ... follow

Cubic yards.

351,325.0
483,783.0
846,919.0

These estimates considerably exceed that made for the Board of Engineers which vened at Memphis, September 4, 1882, but have been deduced from careful su More than one-half the water that escapes into the Tensas Basin flows through the above Arkansas City, and there is now an effort being made by the State of Louis corporations, and private individuals in Arkansas to the effect closure of this line a contract for the work has been made by them. If the reduction of the note be made in time the results of the survey will be incorporated in this report before it submitted to Congress.

FINANCIAL STATEMENT.

Amount allotted		$1,0[illegible]
Expended:		
Instruments and outfit	$51 75	
Services	386 66	
Subsistence	35 50	
Miscellaneous	23 05	
		4[illegible]
Balance available November 1, 1883		5[illegible]

SURVEY OF CHOCTAW BEND REACH.

At the date of the last annual report of the commission the survey party unde sistant Engineer William T. Blunt was in the field. The survey was begun Nove 17, 1882, and completed and the party returned to Wilson's Point December 30, 18

The survey was restricted to the hydrography proper, the shore line as determin Assistant Engineer Ockerson the preceding year being accepted, except where ca banks rendered new locations of shore lines necessary.

The survey extended from Cook's Point to Arkansas City, a distance of 28 miles survey shows that there was not less than 13 feet of water at a stage correspondi a gauge reading of zero on the Arkansas City gauge, or that there existed no obstru to navigation in 1882, low-water season.

A complete project for the improvement of the reach will be submitted with the at the earliest practicable moment. For the present there is no especial demand f improvement, except the revetment of the upper and lower banks of Cook's Point where it is caving and a cut-off imminent. This requires 7 miles of revetment probable cost of $515,000, if carried to the top of the bank, or $210,000 if restricted subaqueous mat. The caving is now back to the cypress swamps, and the material usual in slowly-deposited banks, heavy buckshot, very tough and difficult to cave. banks, however, are wearing quite rapidly, and the configuration of the river point cut-off. The neck now is nearly a mile wide, but low, the water flowing across s eral feet below the ordinary high water. At the up-stream side of the neck is Persia hollow, leading into Long Lake, which occupies the middle of the neck, and drain through Cypress Bayou, on the lower side of neck. The danger lies in this low de sion, already sufficiently lowered to cause quite a deep channel-way across at high w obstructed, however, by a thick undergrowth of cypress, willow, and cottonwood accumulated drift-wood.

The report of Assistant Engineer Blunt is herewith.

FINANCIAL STATEMENT.

To amount allotted		$4,0[illegible]
Expended:		
For services	$1,587 92	
For subsistence	495 06	
For tools and supplies	531 36	
Miscellaneous	65 52	
		2,6[illegible]
Balance available November 1, 1883		1,3[illegible]

L 1.

REPORT OF ARTHUR HIDER, ASSISTANT ENGINEER, UPON OPERATIONS OF THE PROVIDENCE CONSTRUCTION PARTY.

WILSON'S POINT, LA., *November 15, 1*[illegible]

SIR: The following report of operations of the Lake Providence construction from December 1, 1882, to November 1, 1883, is respectfully submitted.

The work undertaken in accordance with your instructions, and that which far been executed, has had in view the following objects:

[illegible] of the width of the river in places where it was excessive, to bring the [illegible] channel within the boundaries fixed in accordance with the original project, [illegible] lowing methods, viz:

[illegible] the closing of the Duncansby and Skipwith chutes by the construction of a [illegible] pile dikes at and near the head of the Duncansby chute. The filling up of [illegible] boat channel, which was between the upper and the lower towheads, by the [illegible] on of a pile dike joining the two bars and the concentration by this means of [illegible] on the right of the towheads, so as to permanently fix the channel next the [illegible] shore and prevent the further caving of the banks in the Skipwith chute.

The closing of the Mayersville chute by a pile dike across the head, and others [illegible] ite further down, and the protection of the channel side of Mayersville Island [illegible] struction of willow mattresses and revetting the front face of the island to [illegible] rther caving, so as to retain the channel of the river in its present location.

The closing and silting up of the chute between the Baleshed Bar and the Mis- [illegible] ore, and the prolongation of the Baleshed Bar at its upper and lower extremi- [illegible] ystem of dikes placed longitudinally and normal to the direction of the current, [illegible] rpose of restricting the width of the river along the Vista and Longwood fronts [illegible] ch limits as would afford a good channel at all stages and prevent the river [illegible] o the Mississippi side into the Baleshed Chute.

The closing of the main channel of the river, which passed between the foot of [illegible] Bar and the head of Stack Island, and bringing it back to the right of Stack [illegible] a system of deflecting dikes located on the Louisiana side at Elton Bar, and [illegible] linal dike, driven across the channel between the lower end of Baleshed Bar and [illegible] of Stack Island, so as to prevent further caving on the Mississippi shore behind [illegible], which had already done a great deal of damage and was increasing at an alarm-

[illegible] ects sought to be obtained at all these points have, to a great extent, already [illegible] mplished, as shown by comparative soundings and surveys furnished by the [illegible] rty, which accompany this report.

[illegible] k of stone to properly secure the revetment work done in November and De- [illegible] last year along the face of Mayersville Island, was the cause of the caving of [illegible] in rear of the mattress work. This would, no doubt, have been prevented had [illegible] een available to properly secure the work.

DESCRIPTION AND EFFECTS OF WORK DONE.

[illegible] sby chute.—During last season a system of low-water dikes was constructed at [illegible] of this chute, the two upper dikes and the main dike at the head consisting of [illegible] of piling, securely braced. These dikes were provided with light brush foot- [illegible] led with stone, laid between the piling, and had screens or open hurdle work [illegible] front of them.

[illegible] ree lower dikes across the chute consisted of single rows of piles with screens or [illegible] lle work in front.

[illegible] se dikes did good service and caused a heavy deposit in the chute during the [illegible] er; in many places the fill extended to the top of the piles.

[illegible] in dikes A and B built last season, connecting the upper and lower towheads, [illegible] ished the result desired, viz, the filling up of the steamboat channel, before ex- [illegible] tween the upper and lower towheads; the fill here also extended nearly to the [illegible] piles. The two bars are now one, and even at high water there is no channel [illegible] them.

[illegible] as been a general enlargement of the bars in front of Duncansby, and a shoaling [illegible] ute along its whole length. At low water this season a skiff would not float [illegible] Duncansby and Skipwith Landing, and at the head of the chute the bar was [illegible] above water, no water at all entering the chute at the upper end. Skipwith [illegible] was moved down nearly a mile nearer the mouth of the chute on account of [illegible] water, to enable steamboats to deliver freight.

[illegible] unt of the rapid caving which took place during the high water in the bend [illegible] lcher's Point, deflecting the main current across the river immediately above [illegible] st the dikes at the head of the chute, seriously threatening the work hereto- [illegible] n, and together with the rapid caving back of the upper Duncansby towhead, [illegible] d been left unprotected; in accordance with your direction, four additional [illegible] s. 5, 6, 7, and 8, were driven during the high-water stages across the chute, [illegible] g as close to the shore as the depth of the water would permit; dike No. 6 con- [illegible] three rows of piles, with a woven mattress 130 feet in width, made in sections [illegible] 00 to 200 feet, overlapping each other, sunk in rear of the dike.

[illegible] e lower dikes, Nos. 7 and 8, were provided with thick grillage mats between [illegible] g. These dikes, where the water was shallow, consisted of two rows of piling

t of the main dike from No. 4 cross-dike to No. 11, to prevent scour. The dike n not provided with a woven mattress in front will have a thick grillage foot-mat structed between the rows of piling, which is now being done. This will complete work as laid out at this locality in accordance with your instructions. The general ct of the work here has been—

st. The enlargement of the Baleshed Bar, both in size and height, and the lengthen- of the bar by accretions, both at its head and at the foot.

d. The filling up of the Baleshed Chute at its upper end, and the enlargement and pening of the channel along the Vista and Longwood fronts.

d. The prevention of the threatened crossing of the river between the foot of Mayers- e Island and the head of the Baleshed Bar, behind the bar, and down the Mississippi re.

th. The filling up of the old crossing between the foot of the bar and the head of ck Island. For location, &c., of this work see accompanying map.

Stack Island.—In order to force the main channel of the river, which flowed down the ck Island chute, on the outside and along the face of the island between it and the ton Bar, a main dike consisting of two rows of piles was driven from a point below foot of Baleshed Bar to the head of Stack Island, leaving the low-water channel from ngwood through the Stack Island chute open for the passage of boats. This dike was ven as a low-water dike; a grillage foot-mat was constructed between the piles, be- ning at the head, as far down as could be put in before the high water covered the e. During high water this work showed good results, forcing the main channel of e river to the right of the island and building a bar to the head of Stack Island, as own by the high-water survey of April, 1883. As the river fell to low-water stage the fference of slope on the chute side and the main river was so great, caused by the sys- m of dikes at the upper end of Baleshed preventing the water from freely entering the per end of the chute, as to render the current extremely rapid through this dike, re- lting in cutting off the top of the bar in front of the dike, and finally carrying away rt of the dike near the head of Stack Island. This was replaced and again broken by sunken barge lodging against it. The break has again been repaired and a grillage ot-mat sunk between the rows of piling. The current passing across the head of ck Island will be materially lessened as the river rises, and the slope on both sides of e island is more nearly equalized. A channel across the head of Stack Island is not ticipated, as at high water the works on Baleshed Bar above, will be sufficient to use the bar to again form at a greater height than before, and it is believed entirely op any water passing into the chute at this point at next low water. For location of is work see map herewith.

Elton Bar.—The work here consisted in the construction of a main dike and six short cross kes, at the head of Elton Bar and in the chute, to act in deflecting the channel across the ver toward the head of Stack Island, auxiliary to the Stack Island main dike, and to se the chute, which was rapidly enlarging, along the Louisiana shore and caving the nks at a very rapid rate, and thus concentrate the water in one channel; as when the rks were put in it was difficult to determine which of these channels the river would ke, behind Stack Island, along the Louisiana shore, or whether it could be concentrated tween Stack Island and the then large Elton Bar. Parts of these dikes were carried ay by drift during the high water, but not before they had accomplished the desired sult. For location of these dikes see map herewith.

METHODS OF CONSTRUCTION.

Dike work.—No material change has been made in the methods employed in the con- ruction of pile dikes from those of last season. The principal change has been in mak- ng the dikes of a greater number of rows of piles. The distance between the rows has en increased from 10 to 15 feet in deep water to allow of more secure bracing as well as e thickness and width of the brush work laid at the foot of the dikes to protect them m the actions of the current and prevent scour. The experience of last season's work owed conclusively that the strongest form of construction is required in order to with- and the force of the current at high water, and has led to putting in work of greater ength where exposed to the action of drift.

Pile driving and bracing.—The plan pursued in building pile dikes has been to drive e front and rear rows of piles simultaneously when it could be done, fasten the longi- piles, and complete the dike by putting in place the cross- ongitudinal and cross-braces, in addition to being fastened to heen well wired with No. 8 wire passed around the pile and m the upper to the lower edge, and made taut by twist- sary on account of the material used for both piles and

drivers are provided with large boiler capacity and pumps capable of
water under a greater pressure. Piles can be sunk deeper with th
others, but the difficulty of handling them in cross-currents reduces t

Between 15 and 20 feet has been the average depth of penetrati
reaching that depth, if further sinking is not stopped by gravel, buck
material, the frictional resistance exerted by the sand along the side o
prevents further penetration. This resistance could not be overcome
of the water-jet or the hammer, or both combined, as the wood of w
composed will not withstand, without splitting, the shock of the ha
a great height. The usual method has been to sink the piles wit
down; the butts are cut off square, and are about 18 inches in diame
not less than 10 inches diameter, and the length of the piles from 35 to
piles is counted as an average day's work for one driver with a crew c
sisting of a foreman, engineer, and five laborers. No special improve
ods followed in pile sinking or in the construction of drivers has sugg
are well adapted for the purposes for which they were designed. F
of hoisting engines are in use, each of which has an advantage in so
the others; on the whole the small horizontal engines have given the
quicker in operation, and, next to the ordinary crab in use on four of t
less for repairs on account of breakage.

Brush mats, hurdles, &c.—The principal dikes have been protected a
vent scouring out, by constructing mats formed of two, three, or four l
pending upon the importance of the dike, rapidity of current, depth of
of cutting out. These layers of brush are placed alternately crosswise
the dike. Stringers, or waling-pieces, as binders, are first hung from th
work for the brush to be laid upon. When the mat is of sufficient thick
are laid on top of the mat connected with those underneath by wires at
leading up from the under stringer pieces, twisted together so as to mak
as close as practicable. The brush is laid so as to extend through the
requiring on some of the dikes three lengths of brush, the brush ends ove
When finished, the mat extends both in front and rear of the dike from
side the dike. The grillage mats thus constructed are then sunk in pla
with rock taken to the dike on barges. When woven mats are placed
to prevent longitudinal scour they have been built similar in constru
mattresses used for the protection of caving banks, and sunk in plac
with rock. For the purpose of preventing the threatened deepening
chute during high water, a brush foot-mat 130 feet in width, made i
100 to 300 feet in length, was woven on a mattress barge in rear of dike

by fastening sacks of rock to the curtain, to counteract the force of the current t in position.

tling or hurdling has been made close by forcing the pieces of brush down so contact with each other, and has been done on either the middle or front the brush mats are built between the rows of piling so as to provide against of the overfall cutting out the sand in rear of the dikes. Sketches giving de- different forms of construction employed in the dikes built and their location n map herewith.

owing statements furnished by Assistant Engineer C. P. Ruple, gives in detail, d form, the work done in dike construction; also an estimated cost for labor ferent classes of work, and amount of material required. All the pile-driving been under his charge, and since June 1, 1882, at which time the foot-mat er Assistant Engineer E. D. Thompson was consolidated with the pile-driving class of work also.

tatement showing dike work from December 1, 1882, *to November* 1, 1883.

Location.	Dike.	Feet driven since December 1, 1882, standing November 1, 1883.	Washed out and replaced during construction.
	Duncansby Bar protection.		340
	Main dike A		250
	No. 1	100	
	No. 3	150	
	No. 5	545	
	No. 6	2,105	275
	No. 7	2,061	
	No. 8	2,310	
	Main dike	2,300*	
	No. 1	805	
	Main dike above 1	1,991	
	Main dike from 3 to 7	2,837	1,021
	Main dike from 7 to 11	6,905	
	No. 1	933	
	No. 2	1,192	
	No. 3	1,172	
	No. 4 of 1883	661	469
	No. 5 of 1883	983	153
	No. 6	1,452	150
	No. 7	1,204	500
	No. 8	1,011	150
	No. 9	1,097	
	No. 10	924	
	No. 11	894	
	No. 12	583	
d.	Main dike	5,250	1,429
	Main dike	943	857
	No. 1	746	54
	No. 2	887	63
	No. 3	975	
	No. 4	300	356
	No. 5	484	40
	No. 6	435	
ls		44,235	6,432

* Three hundred feet of this dike is incompleted.

we dike there is in—

	2,336
	25,187
	14,150
	565
	1,997
l	44,235

Statement showing cost of different items of work, and material required in dike construction

Amount of pay-roll	[illegible]
Subsistence	19,
	109,
Labor loaned other parties, with subsistence	
	109,

Distributed as follows:

1. Pile driving—driving, bracing, and stringing	$78,
2. Brush work—foot-mats, wattling, shore-mats, screens, &c., making and sinking	30,
	109,

Number linear feet dike driven—all kinds, $50,667—cost $1.557 per linear foot; equivalent to [illegible] linear feet double dike—cost, $1.294 per linear foot.

Number linear feet dike driven—as it stands, 44,235—represents a cost of $1. [illegible] linear feet; equivalent to [illegible] linear feet double dike—represents a cost of $1. [illegible] linear foot.

Number linear feet dike driven—washed out—all kinds, 6,432; equivalent to 7, [illegible] feet double dike.

Total number of piles driven, [illegible]; average cost per pile, $3.45	$53,
Total number of braces put on, [illegible]; average cost per brace in place, $1.65	13,
Total number of stringers hung, [illegible]; average cost per stringer in place, [illegible]	11,
	78,

Greatest number of piles driven by one driver in one day, 15 to 22 feet of water [illegible] depth of penetration 17 to 20 feet, was

[illegible] December 1, 1882

[illegible]

[illegible] making and sinking, 60 feet wide

[illegible]

[illegible] made and sunk, from ... $1 50 [illegible]

[illegible] making and sinking, 130 feet wide

[illegible] double dike.

[illegible] piling.

[illegible]

[illegible] linear feet of dike, consisting of two ro[illegible]

[illegible]

[illegible] linear feet		$1[illegible]
[illegible] grillage foot-mats, [illegible] feet wide		[illegible]
[illegible] feet high		[illegible]
		$2[illegible]
[illegible]		
[illegible]	$52 00	
[illegible] at $.90	18 90	
[illegible] at $.75	87 50	
[illegible] at $2 00	60 00	
[illegible]	27 60	2[illegible]
		$4[illegible]
[illegible] tow-boats for charter, repairs, wages, and subsistence [illegible] dike construction		
[illegible] dike		$5[illegible]

[illegible] increased to $6.72 if a woven foot-mat, 10[illegible] in addition to the grillage foot-mat. For a d[illegible]

mat is built; the ends of these rods are connected with lap-rings or clevises. ds are to give the necessary longitudinal strength to the mat, and prevent it asunder while being sunk, and allow it to adjust itself to any irregularities on m. The mat is then further strengthened by binders made of poles placed on ely fastened to the mat with wire to the weaving poles.

le mats, and where the current is swift and the water deep, additional longitu-ength has been obtained by the use of No. 8 wire twisted in the form of a cable, g on top of the mattress, securely fastened at intervals by wire to the weaving The upper end of the mat while being constructed is held in place by lines nder a mooring barge leading to fastenings on the shore above. The mooring placed with one end next the bank, the outer end being kept in place by lines to suitable fastenings on shore. The head of the mat is held up by small lines over the side of the mooring barge, to which they are fastened, which are slacked ad is sunk; additional lines leading from the mat to the bank are placed along at intervals, so connected with it by iron clevises as easily to be freed after the has been sunk in position.

se of the mooring barge is to prevent drift from lodging on the head of the mat, eep it from being submerged until it is ready to be sunk. The mats have been first loading the edge next shore along the slope, with rock, and afterwards by g rock on it, beginning at a suitable distance below the head to allow the mat the bottom without breaking. The head is then sunk last.

t deal of trouble and some loss has been experienced in sinking large matresses. ce has shown that in deep water and where the current is swift the mat can e made too strong, and should not be of a greater length than from 600 to 800 he frictional resistance offered by a mattress of, say, 150 feet in width of this s enormous, and renders the greatest amount of care and precaution necessary nt loss. The methods employed heretofore in sinking large mattresses are not satisfactory, as there is always danger of their loss when the current is swift water is deep. The irregular supply of stone has led to the construction of engths than otherwise would have been built, in order to keep the men employed.

ng.—After sinking the mattresses in place the bank has been graded by the hy-graders to a uniform slope of from 2½ to 3 to 1, ready for the brush revetment; le hand-work is required to trim up the bank, except where it is of sand. The g is a description of the plant and how operated, furnished by Assistant Engi-ury Steubing, who has had charge of the grading:

ption of Plant.—The plant consists of two large pumps placed on barges 110 by 8-foot hold, on the deck of which are the machinery and boilers. A cabin is above the boilers and machinery, which contains sleeping room for 30 men. The

boilers are of steel, and on No. 3 of iron, both of 60,000 T. S. They were tested for a steam pressure of 125 pounds. They are supplemented by an upright auxiliary boiler for cleaning and pumping up main boilers. In front of the furnace is the coal-box, with storage room for 500 bushels of coal. The water to supply each of the main pumps is taken from a well in the bottom of the boat 3 by 3 feet, one on each side, through a 12-inch pipe. The bottom of the well is covered by a strainer made of three-eighths-inch flange iron. This strainer has 2,500 holes of three-eighths-inch diameter, which gives nearly 2½ times the area of the suction pipe. The water is discharged through two 12-inch pipes, one from each pump, into the main pipe, to which the boom-pipe is connected, the joints so arranged where the pipes come together as to allow the boom-pipe to have motion, both perpendicular and horizontal. The length of the boom-pipe is 65 feet, tapering from 12 inches to 8 inches, and consists of 4 flanged pieces, which are bolted together. These pieces of the boom-pipe are lapwelded tubes screwed in to cast-iron flanges and bolted through flange and screw end of tube. The whole is stiffened by two hog-chains, one below extending along the whole length, the upper one on top of the two smallest pieces to which is attached the hoisting rope. The hoisting rope is 1 inch steel wire leading over a pulley on top of the shears, thence to the drum of the hoisting engine. The shears are pine timber, 54 feet long, 12 by 12 inches, the heels butting in iron shoes on deck in a line with the hoisting engine. They are slightly inclined forward and are held by two 1½-inch wire rope guys, which are fastened to the gunwale. The pumps have a capacity to discharge 2,000 gallons a minute, under a pump pressure of 160 pounds.

Method of operating.—The grader is placed in position with one end next the bank, and the stage and boom-pipe lowered so as to almost rest on the ground. When the bank is perpendicular a trench is first cut at the proper slope so as to give a face to begin grading. When a steam pressure of 80 pounds, giving an efficient water pressure in the pumps of 140 pounds, is obtained, the work of grading is begun. A piece of 2-inch gas-pipe, about 4 feet long and pointed at one end, is driven into the ground about 10 or 15 feet from the face, and a little above the middle of the slope. The upper end of this gas-pipe is allowed to remain from 10 to 12 inches above the ground; a piece of iron is fitted into the top of this pipe, to support the nozzle, with holes on each side, into which trunnions on the nozzle fit, so as to admit of motion in any direction. After the nozzle has been fastened in this swivel and the hose connected with the boom-pipe at one of the valves, which are placed at intervals along the pipe for this purpose, two men take hold of the nozzle by means of a lever, which is fastened to it by clamps, and the signal is given to turn on the water; 3 or 4 men are kept ready to lighten up the hose, so as to enable the nozzle-men to point the nozzle in any required direction. The stream issuing from the nozzle is directed against the bottom of the face to undermine it to a depth of from 6 to 12 inches, and in doing this is moved along the whole length of the slope. The earth that has caved through this undermining is then washed into the river. The quickest way to do this is to soak the whole of the loose material first and then direct the stream so as to carry this saturated material into the river, pushing it down by the force of the stream. In undermining, it is always best to commence at the bottom and move upward. If the bank is more than 14 feet high 2 nozzles can be worked with advantage. Where one nozzle is used 11 men are required, while for two, 3 additional men are needed. The force to run one grader requires 1 foreman, 2 engineers, 1 fireman, 1 greaser, 2 nozzle-men, and 4 laborers—total, 11 men. With 2 nozzles working, 15 men are required. A 1¼ or 1½ inch nozzle is then put very near the top of the slope, and undermines the upper one-third of the face, while the 2-inch nozzle does the same with the lower two-thirds, and washes all of the caved material into the river. After the bank has been caved and washed down as far as from 30 to 35 feet from the nozzle this is moved 10–15 feet again. In doing this the water is shut off from the hose, and is wasted through one of the other valves. The difference in the quality of the material that has to be undermined or cut into, the various positions in which the different strata are found underlying each other, height of bank, &c., requires, besides this general method employed, various modifications in special cases of managing the nozzle that can hardly be described, and only learned by experience. This is well demonstrated by the cost of grading.

While grader No. 1 was at Delta Point, opposite Vicksburg, in November and December of 1882, the cost for grading for the first two weeks was 9 cents, from November 20 to 30, 6 cents. In December No. 1 excavated 39,000 cubic yards, at an actual cost of 3¼ cents. Grader No. 3 had in the mean time excavated at Mayersville Island 15,000 cubic yards, at a cost of 2½ cents, the bank consisting entirely of sand, while at Delta it was to a great extent intermixed with strata of hard clay, the different strata lying in unfavorable position for rapid work. In January, 1883, Nos. 1 and 3 together excavated on Mayersville Island 78,000 cubic yards, at a cost of 3½ cents, or, deducting all time lost through inclemency of the weather, &c., of 2.8 cents. The cost of grading in February

accurately calculated, as the grading did not amount to much, and was in-
l delayed through stormy weather and the rising river. Work was stopped
f February.

gain began September 26. Serious delays have been caused by the bursting
Nearly one-half of the time in the first two weeks was lost on this account,
cessary to constantly stop grading and change hose. The hose had been in
ous season. Besides, all outside laborers and foremen were inexperienced,
st of this trouble had been overcome, the rubber valves in the main pumps
o give out, and, as there were only few extra ones on hand, it was thought
t to work the pumps up to their full capacity. The work consequently pro-
aratively slowly. In September, only 3,260 cubic yards were excavated, the
h cannot be properly calculated. In October, in the first ten days, of ten
rs each, 11,395 cubic yards were excavated by No. 1. Since October 11
has been worked both day and night; at night the electric light has been
had been put up in January last. A double crew was put on, changing every
d working twenty out of twenty-four hours. Twenty-five thousand eight
ic yards were thus excavated from October 11 to October 20. On the 20th
eceived to work three crews and to make no stoppage for meals. In the one
fifty-two working hours from October 20 to 29, when work had to be tem-
ped, 25,111 cubic yards were excavated, making a total of 62,306 cubic
ted in the month of October, at a cost of 3 cents per cubic yard. The slope
the last month is smoother and more uniform than any ever made before,
very little or, in some places, no grading even by shovels to make it ready
t. This, I think, is of more importance than to do more excavating with a
r worked slope. I have already mentioned that the usually required water
10 pounds for one nozzle, while for two nozzles the pressure is run up to 160
greater pressure cannot be used very well, as it makes it difficult and dan-
e nozzle-men, besides the liability of bursting hose. By daily observations
the last month it is found that to excavate one cubic yard of earth it takes a
n less than one cubic yard of water under a pressure of 140 pounds, this water
g attained by a steam pressure of 80 pounds and a vacuum of 26½ inches.
ure of 80 pounds of steam it takes 3 pounds of coal per cubic yard of water
rth excavated. In comparing this hydraulic grading of earth with hand
of shovels, I think I may safely assume that the moving by shovel would
per cubic yard. This makes a difference in favor of the hydraulic moving
Grader No. 1 has so far moved about 165,000 cubic yards, and caused a sav-
, of nearly $44,550, or over one and one-half times the original cost. I am
t another month's constant running, with the past experience, new hose,
&c., the cost per cubic yard can be greatly reduced.

ment.—Where revetment has been laid, a grillage of poles is first placed
pe; on this grillage the brush is laid perpendicular to the direction of the
ther set of poles is laid on top of the brush over those underneath, to which
ened with wire to hold the brush in place. The poles are also fastened
stakes driven in the slope, and the revetment covered with stone. On ac-
scarcity of stone last season bags of sand were tried for the purpose of keep-
ment in place, but they failed in accomplishing the desired result; they
orn, and the action of the current washed out the sand, rendering them
e object intended. The following tabulated statement, showing the amount
mplished by the bank-protection party, and its condition November 1, 1883,
nate of the labor, cost, and material required for the different kinds of work,
ished by Assistant Engineer W. M. Childs, who has had charge of this class
the beginning:

[illegible]

Description of work.	Location.	Remaining in good condition November 1, 1883.			Washed away or bank caved back of mattress.			Remarks.
		Length.	Width.	Area.	Length.	Width.	Area.	
		Feet.	*Feet.*	*Squares.*	*Feet.*	*Feet.*	*Squares.*	
Woven mattress	Protection dike at head of Duncansby tow-head				277	135	374	All the work shown here has been washed away by the caving bank of the tow-head. The mattresses are on the bottom and show up at places, but are useless for the purposes for which they were intended.
Do	Duncansby tow-head inside				240	135	324	
Do	do				267	135	360	
Do	do				430	100	430	
Do	Duncansby tow-head outside				288	100	288	
Do	Duncansby tow-head across head				282	96	271	
Do	do				321	50	160	
Do	Mayersville Island between Ranges 53 and 54				4,600	100	4,600	This work is in many places intact on the bottom, but the bank has caved back so as to render the building of a new mat necessary between old mattress and the present bank.
Do	Mayersville Island between Ranges 54 and 55				1,200	120	1,440	
Do	Mayersville Island 225 feet below Range 54				600	75	450	
Do	Mayersville Island between Range 54 and foot of island	5,210	186.8	9,734				
Totals		5,210		9,734	8,505		8,697	
Revetment	Duncansby tow-head inside				425	42	179	
Do	Mayersville Island at head	1,700	58.6	996				
Totals		1,700		996	425		179	

SUMMARY OF ABOVE STATEMENT.

	Feet.	Squares.
Linear feet of mattress in good condition, November 1, 1883	5,210	9,734
Linear feet of revetment in good condition, November 1, 1883	1,700	996
Totals	6,910	10,730
Mattress washed away by caving of tow-head, and from which the bank has caved back on Mayersville Island	8,505	8,697
Linear feet of revetment washed away on Duncansby tow-head	425	179
Total	8,930	8,876

From the above statement an estimate is made of the cost of protecting caving ba with a woven mattress 150 feet wide, the slope graded and covered with a brush m ment held in place with stone, as follows:

In this estimate a square = 100 square feet.

Labor cost for 100 linear feet:

150 squares mattress, at $1.21		$18
40 squares grillage, at $1.61		6
Graded, at 55 cents		5
60 squares revetment, at $1.74		10
Sinking 150 squares mats, at 15 cents		2
Covering with rock 60 squares revetment, at 50 cents		3
		4
Add cost of—		
Material: 153.75 cords brush, at $1.75	$269 06	
Sinking mats, 72.2 yards stone, at $2	144 40	
Covering revetment, 30 yards stone, at $2	60 00	
12.5 cords poles, at $2	25 00	
127.2 pounds spikes, at 5 cents	6 36	
222 pounds wire, at 7 cents	15 54	
1,000 pounds iron rod, at 5 cents	50 00	
Towing, estimated one-sixth of cost of tow-boat service	83 32	
		6
Total cost of 100 linear feet		1,1

Or, per linear foot, $11.21.

SUMMARY.

Work completed from December 1, 1882, *to November* 1, 1883, *and in good conditi*

Number linear feet pile dikes, 44,235.
Number linear feet woven foot mats, 11,945; squares of 100 square feet, 9,388.1
Number linear feet grillage, 24,341; squares of 100 square feet, 9,586.2.
Number linear feet woven mattresses, 5,210; squares of 100 square feet, 9,734.
Number linear feet bank revetment, 2,645; squares of 100 square feet, 2,416.22.

SURVEYS, ETC.

After completing the survey and maps of the low-water survey of October, 188 party under Assistant Engineer Blunt made a hydrographic survey of the Choctaw from Caulk's Point to Arkansas City, occupying them from November 16 to D ber 31, 1882, the party returning to Wilson's Point on the latter date.

During January, 1883, maps were made of the Choctaw Reach survey, of compa soundings at Pilcher's Point, and soundings taken from foot of Island 93 to foot of 94; pile dikes were located, and the lines of regularized river marked by flags on lines on Baleshed Bar. In February and March, soundings for comparison were ta various parts of the reach near Duncansby and Baleshed Bars and Mayersville maps of which were made and are on record. Caving banks were resurveyed, sh changes; new levees located from Duncansby to Homochitto, at Elleslie, and at S and a general preparation made in office and field for a high-water survey. A vari map work was done. In April and May a high-water survey was made from Pil Point to Range 100; contour and section maps made. Sections for comparison sounded in the Duncansby and Baleshed chutes, and similar work done in June, and August.

Assistant W. T. Blunt resigned May 15, and was succeeded by Assistant Hart who took charge May 17. In September a complete low-water survey was made Range 14 to Range 107, shore lines and bars resurveyed, and water surfaces deter for slope in various parts of the reach.

The survey was concluded in October, and maps made of same, and also in re scale for annual reports. This survey shows Duncansby, Mayersville, Baleshe Stack Island chutes closed at low water, and a channel of not less than 10 feet on the Lake Providence gauge through the reach from Ashton to Point Lookout.

The lowest gauge reading for the year was 4.45 (L. P. gauge), October 5, so the period of lowest water during this year there was a channel of not less than *feet* in that part of the river covered by the survey. The maps accompanying a report show all dike and mat work constructed since the beginning of the wor

October 31; also the sand-bars appearing at the time of the September survey, ame bars as they would have appeared in December, 1881, before the construc- commenced, had the river been at the same stage the September, 1883, sur- nade. The Louisiana shore line at Pilcher's Point has caved back 200 yards -water survey of 1882. The maps of comparative sections were taken from f February, 1882, and September, 1883, and show nearly the total change in el since the beginning of dike construction, as but little was done previous to , 1882. Regular ten-day-progress sketches of construction work were furnished y 1, except while the party was engaged on the Choctaw Reach. Since that have been made once a month. All soundings were located either by transit in regular surveys; shore lines and bars, by stadia lines checking upon trian- stations. In September gauges reading the same as the Lake Providence gauge t Lake Providence and Baleshed dikes, Wilson's Point, and Sarah's Island, to slope. Of these, the ones at Baleshed, Lake Providence, and Wilson's Point read twice daily; a gauge has been maintained at the quarter-boat the entire ings being taken at 7 a. m. and 6 p. m.

	Feet.
uge reading October 5, 1883	4.45
ange reading July 6, 1883	35.30
n of river	30.85

Summary of work done by the survey party.

	Choctaw Reach.	Lake Providence Reach.	Totals.
rveys	1	2	3
soundings	2,038	13,235	15,273
ated	73		73
located ... miles	25	25	50
rvations	10	16	26
stations built	36	17	53
stations located	30	12	42
veys		13	13
al soundings		148	148
... miles		25	25
s			57
			47

arty was under the charge of Assistant Engineer W. T. Blunt until May 13, from that time until November 1, under that of Assistant Engineer Hart The above report of the work done, and the tracings accompanying this report, n furnished by Assistant Engineer E. D. Thompson, who is at present in charge rty.

Plant, &c.

lowing is a list of boats and barges, &c., on reach November 1, 1883: 19 quar- ; 1 boat used as machine and repair shop; 1 tow-boat (Vidalia); 3 tow-boats d); 1 steam-launch (Nellie); 1 snag-boat (O. G. Wagner); 2 hydraulic graders; -boat; 9 large mattress-boats; 4 small mattress-boats; 21 pile-drivers; 5 coal- ecked); 46 decked barges (brush and stone); 1 catamaran; 9 coal-barges (open); at; 10 small flats for pile-driving; 60 skiffs; 195 pieces in all.

f these quarter-boats were built here on the hulls of coal-barges, one coal-barge nd one cut down to serve as a mooring-barge. The rakes and sides of 35 barges e-drivers have been caulked, changes and repairs made to pile-drivers, and the epairs incident to so large amount of floating property, kept up. The plant is in good condition except some of the coal-boats, which are worthless. The of some of the barges will need caulking next season.

erage cost of subsisting the employés for each days' labor secured, has been a, including cost of ice during the warm months. The number of days' service each month has been as follows:

r, 1882	14,077	April, 1883	8,565	August, 1883	14,547
1883	19,008	May, 1883	9,721	September, 1883	12,234
, 1883	10,826	June, 1883	13,017	October, 1883	14,841
883	6,785	July, 1883	13,296		

[illegible]

[illegible] better channel through [illegible] At the lowest water [illegible] good [illegible]-foot steamboat [illegible] survey. Difficulties [illegible] of August, September, [illegible] among the men, [illegible] could be obtained [illegible] been supplied. During [illegible] work can be done [illegible] three months from the [illegible] August, September, and [illegible] and become inefficient [illegible] this time. The labor [illegible] the difficulty of obtain[illegible] and the distance it [illegible] prosecution of the work [illegible] to the best advantage [illegible] engineers in charge of [illegible] the interest [illegible] unfavorable conditions [illegible] whatever success [illegible] have also kept their [illegible] finished. To all the [illegible] on the work.

[illegible]

[illegible],
Assistant Engineer in Charge.

[illegible]

[illegible]

[illegible] AT PILCHER'S POINT.

[illegible] POINT, LA., November 5, 1883.

[illegible] the honor to sub[illegible] of the Mississippi [illegible]

[illegible] Willard, who, under [illegible] with a small labor force, [illegible] buildings and making [illegible] of this work.

[illegible] for assistant en[illegible] store-room, 1 stable, 1 [illegible]

[illegible] part of the sea[illegible] described, and ventilators [illegible] in progress the labor force [illegible] mattress.

[illegible] could not be ma[illegible] were made for [illegible] there was no tow-boat [illegible] approaching, with a [illegible] you issued orders [illegible]

[illegible] in the force until [illegible] as possible.

[illegible] Willard [illegible] and I was placed in charge, [illegible]

[illegible] the force, but owing to [illegible] until the early part [illegible] Island, opposite Ashton,

a force of thirty-one laborers; which force was increased as much as could be done out any detriment to the construction of mattress.
e brush party is at present making good progress, and, with the addition of the tram-ow ordered, will supply the three mattress-boats at this place. The shortest haul e brush is one mile, and I think there can be secured from Sarah's Island 8,000 s of choice brush.

DESCRIPTION OF WORK.

e mattresses are constructed in the usual way, upon ways built on mattress-barges, ches being made when the ways are full, by means of lines and captains; the mate-employed being poles, longitudinal and transverse, willow brush, spikes, wire, and rods which run longitudinally through the mattress. These rods are fastened to-er by means of lap-links, and fastened to the weaving-poles by means of staples; at y hundred feet they are fastened to the mat by wire, the connection of the rods be-continuous.
e brush is hauled by mules, on cars properly adapted for the purpose. These cars our feet gauge, and run on a track made of wooden rails, iron rails being employed e curves.
n October 16, the first mat at this place was successfully sunk, and two others com-ced; one at the head of caving bank, the other overlapping the one sunk. The loca-of these mats is shown on tracings accompanying this report. At this date there under construction two mattresses, one 150 feet in width, the other 182 feet in width. h of these is making good progress, and is being pushed as rapidly as possible. The unt of mat made now per day is nearly double that made ten days ago, without any ge in the force employed. This is due to the fact that when laborers come here the k is entirely new to them.
here is in readiness a third mattress barge, which will be put in use as soon as the ly of brush can be increased. One of the mattress boats is supplied with poles by d labor, the other is furnished by a contractor.
e mattress head employed and intended to be used instead of a mooring-barge ed a perfect success; a drawing of this mattress head is submitted with this report. mattress head consists of two chords, 20 feet apart, with a series of cross and diag-bracing, and a hog-chain, as shown in drawing.
e up-stream chord is 12 inches in width by 30 inches in depth; the lower one 12 es in width by 19 inches in depth; these chords are one hundred and sixty-three feet ngth, and have a camber of 6 inches; they are constructed of pine plank. During construction of the mattress it is by lines anchored to the mattress head. During sinking, the mattress head is sunk with the mat, and by means of a lever and trips mattress head is released from the mat and again used. The method employed in ing and releasing the mattress head is as follows: The mat to which it was attached 1,228 feet in length by 152 feet in width. The sinking of the mat was commenced the center and the mat loaded with stone both ways; in this way the entire mat gone over and sunk to a depth varying from 10 feet to 35 feet.
wo barges were then lashed together side by side, and about 8 feet apart, and placed ut 50 feet from mattress head; and this portion of the mat loaded for the second e. These barges were by means of lines pulled up stream and toward the mattress d, the stone being thrown from each barge on the up and down stream sides. This ing caused the mattress head to sink rapidly. Previous to this second loading of mattress, the depth of water at outer end of mattress head was carefully taken, sounding line was made fast to lower chord of mattress head and held by a man skiff, the object of this was to know how rapidly the mattress head was sinking. en it had sunk to ⅞ of the entire depth, ten men who were ready to haul on a line e fast to ring at upper end of lever were ordered to pull. The mattress head was nce released, and the head of the mat being relieved of its buoyancy sank rapidly to bottom.
he snag-boat Wagner reported for duty on September 21, and has been employed in ing snags from this bend; she was employed 7 days pulling piles from dike at head Duncansby chute, and has lost 5½ days in making repairs.
owboat Pearl reported for duty September 22, and has, with the exception of a few s, been constantly employed.

SUMMARY OF WORK DONE.

-ice and sleeping-room, 28 by 22 feet; 1 kitchen and dining-room, 30 by
-nary, 32 by 20 feet; 1 warehouse, 32 by 20 feet; 1 stable, 20 by 15 feet;
-p, 14 by 16 feet; 1 mattress head.
-ed on 3 quarter-boats.

Roofs of 4 quarter-boats painted.

Mattress constructed: 928 by 152 feet, 300 by 235 feet, 610 by 150 feet, 585 by [illegible] feet.

Mattress sunk: 928 by 152 feet, 300 by 235 feet.

Snags pulled: 154: piles pulled, 122; cords of brush cut, 2,050; cords of brush hauled and loaded on barges, 1,109; cords of poles cut, 94.

Feet of track laid, 3,324: feet of track corduroyed, 1,872.

Timber has been cleared from the bank below Pilcher's Point for a distance of [illegible] feet and 400 feet in width, and above Pilcher's Point for a distance of 1,480 by 160 [illegible] in width.

Respectfully submitted.

J. E. TURTLE,
U. S. Asst. Engineer.

Capt. L. W. S. MARSHALL,
Corps of Engineers, U. S. A.

L 3.

REPORT OF H. ST. L. COPPÉE, ASSISTANT ENGINEER, UPON IMPROVEMENT OF VICKSBURG HARBOR.

OCTOBER 21, 1883.

CAPTAIN: I have the honor to submit herewith a report on the improvement of Vicksburg Harbor, dating from December 1, 1882, to October 10, 1883, accompanied by maps, profiles, tables, &c.

Very respectfully, yours,

H. ST. L. COPPÉE,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

REPORT ON IMPROVEMENT OF VICKSBURG HARBOR, FROM DECEMBER 1, 1882, TO OCTOBER 10, 1883.

I have divided the following report, in accordance with the progress of the work, into five parts, viz: The protection of Delta Point, La.; dredging in Vicksburg Harbor proper; survey of harbor and Mississippi River in the vicinity; results obtained by comparison of surveys from 1877 to 1883: and tables.

The protection of Delta Point, with a view to stopping the caving of its banks and keeping the channel of the river as near its old bed as possible, was commenced in [illegible] and carried on in succeeding years up to the season of 1882, under the direction of [illegible] W. H. H. Benyaurd. During this time a spur-dike was constructed with brush and stone, two screen-dikes built and anchored in the current, and 144 mattresses sunk (as shown on maps), the last mattress sunk in 1881, occupying a position just below the spur-dike. In October, 1882, I commenced the further revetment of the point, under your directions. In compliance with an order received from you November 24, 1882, I forwarded to your office a report, accompanied by maps, giving the positions and extent of the work accomplished at Delta, up to December 1 of that year; also a description of the methods adopted and under way, for protecting the banks against the action of the current. These methods were not changed, but the work carried on in the same manner to its completion, with the one exception, that the plan of driving piles through the upper edge of the mattress was abandoned, so that no obstructions would be offered to the sinking of mats on the upper graded bank during high water, in place of revetment, which would be impossible to build.

December 1, 1882, the condition of the work was as follows:

Grade of upper bank, finished to a slope of about 2½ to 1	linear feet	1,[illegible]
Grade partly finished	do	[illegible]
Poles or frame-work on upper bank	do	[illegible]
Upper bank revetted with brush	do	[illegible]
Upper bank revetted with brush and covered with stone	square yards	2,[illegible]
Foot-mats built, 35 feet wide	linear feet	4[illegible]
Foot-mats built and sunk, 35 feet wide	do	1[illegible]
Mattresses constructed, 144 feet wide	do	1,[illegible]
Mattresses constructed and sunk, 144 feet wide	do	8[illegible]
Piles driven through edge of mattresses		[illegible]

e the water was standing at 13.7 feet on the gauge, and all other conditions pushing the work. About 440 men were employed; 90 at the brush camps, : camp, 322 constructing mattresses, revetting the upper bank, grading with and 18 on the hydraulic grader. This force was as great as we could pos- work, with the plant in use. The work was carried on, the force employed pproximating the above number, until February 10, 1883, when, owing to the water and lack of funds, it was abandoned. January 5, 1883, the hydraulic having cut the banks to the required slope as far down the river as it would mattress during the season, returned to Wilson's Point, having during its from November 7 to January 5, graded 3,500 linear feet of bank. During the ember it moved 38,790 cubic yards of earth. Operations during the month of e carried on with much difficulty, owing to the high stage of water, swift onstant annoyance occasioned by the drift in the river; at one time the pres- : latter on our mattress barge, was so great as to break the lines connecting oating mattress, and carry it down the river nearly a mile. The mattresses k with trouble, the drift having accumulated under them to such an extent onstruction. During the progress of the work, *i. e.*, from October 10, 1882— 10, 1883—no portion of the mattresses, foot-mats, or bank revetment was lost. omplished during this time was as follows:
nstructed and sunk:

No. 1	feet	130×184
No. 2	do	140 365
No. 3	do	144 358
No. 4	do	144 280
No. 5	do	144 87
No. 6	do	144 300
No. 7	do	144 285
No. 8	do	144 400
No. 9	do	144 460
No. 10	do	144 408
No. 11	do	136 475
No. 12	do	144 80
No. 13	do	80 745
No. 14	do	140 45
No. 15	do	140 40
No. 16	do	150 40

nstructed and sunk, about 35 feet wide	linear feet	830
d and covered with stone	do	3,500
		96
, grader No. 1, 3,500 feet; , shovels, 1,000 feet	linear feet	4,500
ork:		
l, but not stoned	feet	400×25
rame work finished	do	112 18

n and extent of the work is shown in plan, as on accompanying plate. The ting the bank at Delta—*i. e.*, the cost for labor and materials, not including es, purchasing tools, rope, general outfit, towing, superintendence, assist- &c.—was as follows:

Cost of constructing and sinking 100 *feet of mattress* 144 *feet wide.*

rds, at $2.53	$151 80
t 32 cents	53 12
170 pounds, at 5 cents	8 50
h, 50 pounds, at 5 cents	2 50
0 pounds, at 4 cents	1 20
ic yards, at $1.90	114 00
y, at $1.65 (including subsistence)	82 50
; $2.15 (including subsistence)	2 15
ner, $1.90 (including subsistence)	1 90
	417 60
r foot of mats	4 17

Cost of 100 feet of upper bank revetment, 75 feet wide.

[illegible]	$75 ..
[illegible]	45 ..
[illegible]	14 ..
[illegible]	3 ..
[illegible]	255 ..
[illegible] (including subsistence)	45 ..
[illegible] (including subsistence)	2 ..
[illegible] (including subsistence)	1 ..
Total	517 ..

Cost per linear foot of revetment, $5.17.

The excessive cost of willow brush and poles used in the above estimate was due to the long haul necessary in order to obtain them of the desired size and quality and in sufficient quantities, and also to the soft condition of the bar from which they were secured.

Cost of grading 100 feet of bank 75 feet wide [illegible] above water surface. [illegible] cubic yards [illegible].

Grading with shovels:

[illegible] (including subsistence)	$3.. ..
[illegible] (including subsistence)	4 ..
[illegible] (including subsistence)	1 ..
[illegible]	14 ..
Total	40. ..

Cost of grading per linear foot, [illegible].

RECAPITULATION.

Cost of [illegible] per linear foot	$4.1.
Cost of revetment per linear foot	5.1.
Cost of grading per linear foot	4.0.
Cost of protecting bank per linear foot	13..

February [illegible] the water stood 22.7 feet on the Vicksburg gauge, and continued at a high stage [illegible] until early in July. During [illegible] of the revetted bank, making [illegible] incomplete and [illegible]. In the latter part of [illegible] of the coal barges [illegible] the Lake Providence [illegible] with the balance of the [illegible] to Vicksburg.

DREDGING IN VICKSBURG HARBOR.

The first part of the original plan recommended by the Board of Engineers (January, [illegible]) for the improvement of the harbor, [illegible] the protection of [illegible] Point, having been accomplished, the second part, of dredging a canal and basin in front of the city, was commenced April [illegible]. November [illegible] the contract for dredging was awarded to Mr. [illegible], the understanding being that in accordance with the specifications [illegible] work commence [illegible] February 1, 1883, and [illegible] to the full extent of the available funds [illegible] by October 1 of the same year. April [illegible], or two months after the date specified in the contract, the dredge Thos. B. Herndon was towed into the harbor, and April [illegible] commenced excavating; your instructions being to dig a basin [illegible] feet long by [illegible] feet wide, down to a horizontal plane passing through the zero of the gauge, thence to the same plane, a canal into the lake 150 feet wide by approximately 1,500 feet long (the position of canal and basin is shown on accompanying plate [illegible]), thence to move the dredge to the southwest entrance to the lake, and cut a channel through the bar [illegible] of sufficient width and depth to allow [illegible] to enter with a view of giving Vicksburg a temporary harbor during low water. The dredge was [illegible] dredge, capable of excavating, when well handled, [illegible] yards in twenty-four hours.

Up to April [illegible] work was carried on in the day-time only, but from that day until

s abandonment on account of low water the dredge worked twenty-four hours each ay, with the exception of Sundays, which were used for repairs to machinery. Two ispectors were employed by the Government to measure the amount of material excavated and placed in scows, each inspector remaining on the dredge twelve hours, thus ividing the day into two watches, as was also done by the crew employed by the contractor. Two scows were used to convey the material excavated to the point designated y the inspector. The capacity of the scows were respectively 116 and 266 cubic yards. The material was dumped in the low ground in the willow ridge opposite the compress (as shown on map), the haul or tow being about one mile, round trip, from the center of the basin. At first it was impossible to dredge to the desired plane (zero), as the guide or bucket-poles were not of a sufficient length to allow of the bucket reaching that depth, thus making it necessary to go over a portion of the proposed basin twice. It will be noticed by a glance at the gauge table that during the early stages of the work, nearly two months, the water was above the forty-foot mark; the dredging was necessarily slower and performed with greater difficulty than afterwards, when the river fell to a lower level. During the progress of the work there were numerous break-downs and delays, in many instances caused by bad management on the part of those representing the contractor. At times the force employed on the dredge was not sufficient to do the work properly. There were also some delays caused by the careless handling of boats that frequented the harbor, running over the guide stakes, lights, &c. This, however, was soon remedied by cautioning the pilots, it being to their interest to help rather than to retard the work. The dredging was at first confined to the basin, the material being taken out in cuts 40 feet wide, but not to the zero, as stated above, because of the shortness of the bucket-poles. Six parallel cuts were taken out the entire length of the basin, commencing at the western edge and working eastward to a plane about 5 feet above zero; thence, May 26, the dredge was moved to its eastern edge, and the water being sufficiently low commenced excavating to the zero. Four cuts were made working westward with the exception of a small ridge in front of and close to the elevator, which it was impossible to dig with the bucket in use. As the contractor claimed that this material was rock, I had borings made and found it to be as I anticipated, simply a hard, compact deposit.

The contractor was requested to send us a bucket capable of removing this, but did not comply with the request. July 18 the condition of the work was as follows (all the operations having been confined to the basin):

Four cuts or 160 feet from western edge excavated to + 5 feet. Four cuts or 160 feet from eastern edge excavated to zero, leaving 160 feet to be re-dredged in order to finish the basin to the required depth. There was practically no more work done in the basin. As the water at this time (July 18) had fallen to 38 feet on the gauge and was going down rapidly, you thought it expedient before finishing the basin to make a couple of cuts (a canal 80 feet wide to zero) to deep water in the lake, in order, if possible to prevent the necessity of moving the wharf boat and general river business to the lower landing. The dredge was therefore placed in the temporary canal, and worked there until August 2, when you ordered her moved to the southwest entrance to the lake. The lower entrance to the landing was at that time closed, and the upper or southwestern shoaling rapidly. The temporary canal was then in the following condition: One cut 40 feet by 2,500 feet excavated to zero, and a portion of a second 1,000 feet to the same plane. August 3, dredging commenced at a point on King's Bar, marked on the map West Pass, in twelve feet of water (the gauge reading 31.5 feet) and carried on up to the 24th. The material to be moved was of such a consistency (compact sand) that the soft-bottom bucket had to be abandoned, and one shipped by the contractor from Mobile used in its place. This worked to much better advantage, but was not a success. Numerous expedients were resorted to, but the plan of making a passage through the bar had finally to be abandoned and the dredge towed back to the second cut in the temporary canal. The accompanying map and profiles show the position and dimensions of the excavation at West Pass; its present condition is not all due to the dredging, but in great part to the scouring force of the current running from the lake into the river at that point. The probability is that a rising river will fill this up again in a short time. From August 24 until September 18 the dredger worked in the temporary canal. At the latter date the gauge-reading was 7.4 feet, the dredge drawing 7.5 feet. As your orders were not to excavate below the zero plane, it was impossible to continue until the river should rise. The dredge was therefore removed to deep water in the lake, and as ... continued to fall steadily, has remained there to date. Should the con... to remove his outfit, the time for finishing the contract (Sept. 30) having ...ll be impossible, all access to the main river being closed. During the ... work, a record of the material dredged was kept, giving the excavation ...watch, day, &c., the causes of delay, and general log.

... gives the amount of material excavated each month, that taken from

basin, temporary canal, and West Pass, and totals. The total amount, 350,035 cubic yards, at 12.1 cents, $42,354.23, minus 10 per cent., $38,118.81, has been paid the contractor in monthly estimates. The condition of that portion of the lake where the excavation was made at the present time, to which I will refer in the results obtained by comparison of surveys, will show a decided filling or sliding in from the sides, giving a very poor idea of the amount of material originally dredged. There was also a deposit taking place during the entire time of dredging, as shown on the profiles, Plates XII and XIII.

SURVEY.

Early in September, in accordance with instructions to make a thorough survey of the harbor and Mississippi River in the vicinity, for the purpose of comparing the data thus obtained with the surveys of previous years, with a view to ascertaining the probable additional cost of dredging, should it be deemed expedient, and noting the changes that had taken place in the main river, I put a party into the field and obtained all the desired information by the 10th instant. The work in the inner harbor was pursued with some difficulty, being not only expensive but dangerous, the mud-bar in front of the city being in such a condition as to necessitate the laying of plank in order to obtain the elevation of the ground sounded the year before. The laborers employed in placing the plank ways were numerous times immersed up to their armpits, and but for the boards to which they clung would have disappeared entirely. This extremely soft deposit extended the entire length of the proposed permanent canal and basin, with the exception of a small strip of bar at section No. 1; the ground there, being much higher, was hardened by the sun, but one foot below the surface was very soft, as I ascertained by attempting to drive my horse over it.

The survey consisted in remeasuring and either leveling over or sounding the sections sounded in 1881 and 1882 in the inner harbor, twenty-three in number, running a line of levels from Ryan's lower saw-mill to a point on King's Bar opposite the Delta wharf-boat, obtaining the low-water line of King's Bar, the middle-ground bar, the bar above Delta, and the bar just below the revetted portion of the Delta Point bank, sounding twelve sections in the upper lake and fifteen sections in the main river. A meander line was run up to King's Point. Levels were also carried from the gauge at Kleinston to the gauge in the lake, the difference in elevation of the water in the river and lake obtained, cross-sections made of West Pass, and cross-sections of the excavated basin obtained every 100 feet, giving the slopes the sides had assumed. Posts were planted at the end of each section in the inner harbor for future use. The soundings were made in every instance as nearly as possible on sections used in previous years, in order to better compare results. The levels and soundings are referred to the zero of the gauge at Kleinston, no deduction being made in the case of soundings in the main river for slope, but simply referring them to the datum by subtracting the reading of the gauge at the time of sounding from the depth obtained.

RESULTS.

The results of this survey, and those made in the past, I have collected and arranged in the form of tables, which will explain themselves, leaving but little to be added. The data from which the changes during 1877, 1878, 1879, and 1880 were obtained were very meager, and in most instances but approximate; but will serve to show the general conditions which existed during those years, and the change which has taken place in the inner harbor since the time of the cut-off in 1876; a gradual filling has taken place which will continue until the lake is free from all access to the muddy water of the river unless some means are adopted to cut off the current that flows around De Soto Island during high water. This current has existed since 1877 to a greater or less extent, having a velocity in that year of nearly one-fourth mile per hour. In 1882 it was hardly perceptible, float observations made in July of that year showing practically no velocity, but during the last high water it traveled from Ryan's mill to the compress at the rate of one-half mile per hour, gradually becoming slower as it reached the northern end of the island. This has caused a more rapid filling of the area than has taken place for years.

Glass Bayou, which enters the lake at the northern boundary of the city, has also been the cause of considerable filling, bringing during every heavy rain a great quantity of mud from the adjacent hills. The changes that have taken place in the main river during the last high water, as shown on the accompanying map, are to a great extent a repetition of what occurred the year before. The bar above Delta has moved down stream 600 feet; some caving has taken place at King's Point. The King's Point Bar has been split, the sand taken from its former crest being deposited in the form of a middle ground, outside of its old position and extending

[illegible] actually the upper entrance to the lake, and [illegible] Kleinston landing. The bank has caved to some [illegible] there is a strong eddy current there, the water [illegible] the Kleinston front. The bar below the revetted [illegible] at its upper end 100 feet, and 1,000 feet below, [illegible] of the revetment at Delta Point and found [illegible], built in 1879, has been swept away, carrying [illegible]; also at a point (marked on drawing of Delta [illegible] was placed, there has been some caving. To [illegible] old dike, and at this mud flat, to insure the perma[illegible], it will be necessary to put down 500 linear feet of [illegible] inner harbor are shown on the profiles, and in tables

[illegible]STIMATES FOR DREDGING.

[illegible]	$80,000 00
[illegible] to 15 foot plane, canal, 250 by 4,800; basin, [illegible] cubic yards, at 15 cents	335,333 25
[illegible] $1\frac{1}{2}$ to 1, canal and basin same as in second [illegible] cubic yards, at 15 c[illegible]	347,279 25
[illegible] 1883, canal and ba[illegible] in map, including tempo[illegible] plane, slopes 5 to [illegible]ing 40 per cent. for expan[illegible] measured in scows	389,980 36
[illegible], 1883, slopes 8 to [illegible] one side and natural slope [illegible] other; permanen[illegible]al, as shown in map, exca[illegible] =3,789,632.7 cubic y[illegible]+40 per cent. = 5,305,485.7,	795,822 85
[illegible] the basin during the y[illegible] 244,456 cubic yards, at $12\frac{1}{10}$	29,579 07
[illegible] be spent in order to fin[illegible] permanent canal and basin, [illegible] for fill during the progre[illegible] the work	766,243 68

[illegible] in the harbor be as grea[illegible]uring the next high water, this estimate [illegible] be increased over $300,0[illegible] making the total cost, approximately, [illegible] The slopes assumed by the d[illegible]ed portion of the lake are shown on the

TABLE No. 1.

[illegible]	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.
		1883.		1883.		1883.		1883.	
[illegible]	13.70	Jan. 1	11.90	Feb. 1	24.70	Mar. 4	42.70	Apr. 4	43.90
[illegible]	13.50	Jan. 2	12.80	Feb. 2	26.60	Mar. 5	42.80	Apr. 5	43.80
[illegible]	13.20	Jan. 3	13.75	Feb. 3	28.30	Mar. 6	42.90	Apr. 6	43.70
[illegible]	13.00	Jan. 4	14.70	Feb. 4	29.80	Mar. 7	43.05	Apr. 7	43.95
[illegible]	12.80	Jan. 5	15.50	Feb. 5	30.70	Mar. 8	43.10	Apr. 8	43.85
[illegible]	12.60	Jan. 6	16.40	Feb. 6	31.40	Mar. 9	43.10	Apr. 9	43.80
[illegible]	12.30	Jan. 7	17.00	Feb. 7	31.90	Mar. 10	43.15	Apr. 10	43.75
[illegible]	12.00	Jan. 8	17.30	Feb. 8	32.10	Mar. 11	43.20	Apr. 11	43.70
[illegible]	11.75	Jan. 9	17.30	Feb. 9	32.40	Mar. 12	43.20	Apr. 12	43.60
[illegible]	11.65	Jan. 10	17.50	Feb. 10	32.70	Mar. 13	43.25	Apr. 13	43.60
[illegible]	11.60	Jan. 11	17.55	Feb. 11	32.90	Mar. 14	43.25	Apr. 14	43.60
[illegible]	11.55	Jan. 12	17.40	Feb. 12	33.45	Mar. 15	43.30	Apr. 15	43.55
[illegible]	11.50	Jan. 13	17.30	Feb. 13	34.10	Mar. 16	43.25	Apr. 16	43.55
[illegible]	11.40	Jan. 14	17.50	Feb. 14	34.90	Mar. 17	43.20	Apr. 17	43.30
[illegible]	11.20	Jan. 15	17.20	Feb. 15	35.80	Mar. 18	43.20	Apr. 18	43.30
[illegible]	10.90	Jan. 16	16.80	Feb. 16	36.70	Mar. 19	43.20	Apr. 19	43.20
[illegible]	10.50	Jan. 17	16.40	Feb. 17	37.70	Mar. 20	43.15	Apr. 20	43.10
[illegible]	9.90	Jan. 18	16.10	Feb. 18	38.40	Mar. 21	43.05	Apr. 21	43.00
[illegible]	9.50	Jan. 19	16.00	Feb. 19	38.95	Mar. 22	43.00	Apr. 22	43.00
[illegible]	9.30	Jan. 20	15.90	Feb. 20	39.60	Mar. 23	42.95	Apr. 23	42.11
[illegible]	9.15	Jan. 21	15.90	Feb. 21	40.35	Mar. 24	42.80	Apr. 24	42.10
[illegible]	8.80	Jan. 22	15.90	Feb. 22	40.60	Mar. 25	42.85	Apr. 25	42.90
[illegible]	8.45	Jan. 23	15.90	Feb. 23	41.05	Mar. 26	42.80	Apr. 26	42.80
[illegible]	8.00	Jan. 24	16.00	Feb. 24	41.55	Mar. 27	42.70	Apr. 27	42.70
[illegible]	7.80	Jan. 25	16.30	Feb. 25	41.85	Mar. 28	42.80	Apr. 28	42.60
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.05	Mar. 29	43.00	Apr. 29	42.50
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.20	Mar. 30	43.30	Apr. 30	42.40
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.25	Mar. 31	43.60	May 1	42.30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.35	Apr. 1	43.80	May 2	42.20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.55	Apr. 2	43.90	May 3	42.10
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.65	Apr. 3	43.90	May 4	42.00

TABLE No. 1—Continued.

Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gaug
1883.		1883.		1883.		1883.		1883.	
May 5...	41.11	June 6...	38.80	July 8...	39.70	Aug. 9...	22.10	Sept. 10...	9.
May 6...	41.11	June 7...	38.10	July 9...	39.70	Aug. 10...	23.00	Sept. 11...	8.
May 7...	41.10	June 8...	39.90	July 10...	39.70	Aug. 11...	23.10	Sept. 12...	8.
May 8...	41.90	June 9...	39.00	July 11...	39.70	Aug. 12...	23.30	Sept. 13...	8.
May 9...	41.80	June 10...	39.10	July 12...	39.70	Aug. 13...	23.10	Sept. 14...	7.
May 10...	41.90	June 11...	39.10	July 13...	39.60	Aug. 14...	23.00	Sept. 15...	7
May 11...	41.80	June 12...	39.10	July 14...	39.40	Aug. 15...	22.10	Sept. 16...	7
May 12...	41.80	June 13...	39.10	July 15...	39.20	Aug. 16...	22.10	Sept. 17...	6
May 13...	41.70	June 14...	39.10	July 16...	38.10	Aug. 17...	22.40	Sept. 18...	6
May 14...	41.60	June 15...	39.00	July 17...	38.02	Aug. 18...	21.11	Sept 19...	6
May 15...	41.50	June 16...	39.00	July 18...	37.10	Aug. 19...	21.40	Sept. 20...	5
May 16...	41.30	June 17...	39.10	July 19...	37.10	Aug. 20...	20.10	Sept. 21...	5
May 17...	41.10	June 18...	39.10	July 20...	36.40	Aug. 21...	20.20	Sept. 22...	[illegible]
May 18...	40.10	June 19...	39.20	July 21...	....	Aug. 22...	19.40	Sept. 23...	[illegible]
May 19...	40.60	June 20...	39.40	July 22...	35.70	Aug. 23...	19.20	Sept. 24...	[illegible]
May 20...	40.10	June 21...	39.50	July 23...	34.10	Aug. 24...	18.60	Sept. 25...	[illegible]
May 21...	39.70	June 22...	39.50	July 24...	34.40	Aug. 25...	18.00	Sept. 26...	[illegible]
May 22...	39.00	June 23...	39.60	July 25...	34.20	Aug. 26...	17.40	Sept. 27...	[illegible]
May 23...	38.50	June 24...	39.60	July 26...	34.10	Aug. 27...	16.10	Sept. 28...	[illegible]
May 24...	37.11	June 25...	39.90	July 27...	34.00	Aug. 28...	16.00	Sept. 29...	[illegible]
May 25...	37.70	June 26...	39.80	July 28...	33.11	Aug. 29...	15.50	Sept. 30...	[illegible]
May 26...	37.70	June 27...	39.80	July 29...	33.60	Aug. 30...	14.90	Oct. 1...	[illegible]
May 27...	37.80	June 28...	39.70	July 30...	33.00	Aug. 31...	14.20	Oct. 2...	[illegible]
May 28...	37.11	June 29...	39.70	July 31...	31.50	Sept. 1...	13.80	Oct. 3...	[illegible]
May 29...	38.00	June 30...	39.70	Aug. 1...	30.30	Sept. 2...	13.20	Oct. 4...	[illegible]
May 30...	38.20	July 1...	39.00	Aug. 2...	29.00	Sept. 3...	12.10	Oct. 5...	[illegible]
May 31...	38.40	July 2...	39.60	Aug. 3...	27.00	Sept. 4...	12.40	Oct. 6...	[illegible]
June 1...	38.00	July 3...	39.60	Aug. 4...	26.90	Sept. 5...	11.11	Oct. 7...	[illegible]
June 2...	38.60	July 4...	39.60	Aug. 5...	25.60	Sept. 6...	....	Oct. 8...	[illegible]
June 3...	38.70	July 5...	39.60	Aug. 6...	24.60	Sept. 7...	....	Oct. 9...	[illegible]
June 4...	38.70	July 6...	39.70	Aug. 7...	23.70	Sept. 8...	10.20	Oct. 10...	[illegible]
June 5...	38.80	July 7...	39.70	Aug. 8...	23.00	Sept. 9...	9.70		

TABLE No. 2.—*Showing fill every 100 feet on King's Bar (or section 1 continued) f* *1882 to 1883.*

Distance.	Fill.	Distance.	Fill.	Distance.	Fill.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
100	13.0	1,000	9.4	1,900	18.5
200	12.0	1,100	8.4	2,000	14.0
300	*14.0	1,200	8.5	2,100	12.6
400	17.0	1,300	8.2	2,200	12.8
500	18.8	1,400	9.1	2,300	9.6
600	18.6	1,500	9.5	2,400	†9.2
700	16.6	1,600	11.6	2,500	8.4
800	14.0	1,700	14.2	2,600	6.4
900	12.0	1,800	17.6	2,700	6.4

* Middle of canal. † Middle of west pass.

TABLE No. 3.—*The maximum fill, in inner harbor, within the limits of canal, from* 18 1883, *omitting sections sounded in* 1880, *which are not accurate enough for compariso*

Sections.	Fill, in feet.				
	1877 to 1878.	1878 to 1879.	1879 to 1881.	1881 to 1882.	1882 to 1883.
No. 4........	20	12	12	6	6
No. 13........	13	12	Approx. 0	4	8
No. 14........	17	7	Approx. 0	2	9
No. 15........	13	10	Approx. 0	1	10
No. 16........	16	6	Approx. 0	Approx. 1	10
No. 17........	6	5	Approx. 0	Approx. 1	9
			1879 to 1883.		
No. 24........	23	13	16	Approx. 0	Approx. 5

No. 4.—*Fill in inner harbor within the limits of the slopes of canal and basin from to 1882 (see profiles). In the fractions, the numerator denotes the distance measured the shore edge of the slope, the denominator, the fill at that distance.*

Sections.	Fill in feet.																	
	0/0	45/5.3	70/8.6	95/9.7	100/11.0	145/10.6	175/10.4	195/8.2	245/3.8	295/06	300/0.0							
	0/0	50/0.8	100/2.4	150/5.0	200/10.0	250/5.8	300/2.0	350/5.2	370/7.2	400/10.4	410/11.0	450/11.2	460/11.8	500/7.9	550/3.0	580/0.0		
	0/02	25/1.4	75/2.6	125/4.5	175/5.9	225/6.8	275/8.6	325/9.1	375/10.0	425/7.0	4.75/5.0	525/0						
	0/0	10/1.2	60/3.5	110/3.4	160/5.2	210/6.0	260/6.0	310/5.2	360/5.0	410/5.2	460/6.0	510/5.8	530/6.0	560/3.0	587/0			
	0/0	20/2.4	50/1.4	60/1.1	100/3.8	150/6.4	200/5.0	300/4.0	350/5.6	400/4.4	450/5.2	500/5.8	550/5.0	590/0				
	0/0	50/0.8	100/1.0	150/1.1	200/1.8	250/2.0	300/2.6	350/2.8	400/2.8	450/3.8	500/3.8	550/3.8	570/3.8	600/0.4	605/0			
	0/0	15/4.8	30/2.6	80/1.2	130/0.4	1.80/1.6	2.30/1.4	280/2.0	330/24	380/2.4	430/2.4	480/2.6	530/2.2	550/2.0	565/0			
	0/0	8/2.8	30/2.4	50/2.0	80/2.4	95/2.6	130/2.4	180/1.8	230/2.8	280/2.8	300/2.8	330/2.2	380/2.6	430/2.4	455/2.6	475/0		
	0/0	10/4.8	30/3.2	80/3.6	130/4.2	180/4.0	230/4.0	280/4.0	330/4.2	380/4.4	430/3.6	480/3.8	495/4.0	530/0				
	0/0	10/1.6	60/1.0	110/1.0	160/1.0	185/0.8	210/1.8	260/3.4	310/4.0	360/4.1	410/4.4	460/5.0	510/0					
	0/0	10/1.0	60/3.2	110/2.0	160/4.6	210/3.2	260/2.6	310/2.0	360/2.4	410/3.0	450/3.2	460/1.6	475/0					
	0/0	10/0.8	60/0.6	110/0.8	160/1.2	210/2.8	260/4.0	310/3.4	360/3.4	410/3.6	445/0							
	0/0	15/3.2	65/5.0	85/6.0	115/3.4	165/3.0	215/3.2	265/3.2	315/2.8	365/2.6	415/2.8	443/2.8	465/0					
	0/0	10/3.6	50/2.0	75/1.6	100/2.6	150/1.6	200/1.4	250/0.8	300/0.2	350/0.8	400/0.9	450/1.0	500/0.8	550/1.4	600/1.2	650/1.2	700/0.8	710/0
	0/0	50/0.4	100/0.8	150/0.4	200/0.0	250/0.1	300/0.6	350/0.1	400/0.4	450/0.6	475/1.0	480/0						

ble No. 5 showing mean fill and areas, calculated from above co-ordinates.

No. 5.—*Mean fill and areas of fill in inner harbor within the limits of the slopes of the canal and basin from* 1881 *to* 1882.

Section.	Mean fill.	Area.
	Feet.	*Sq. feet*
No. 1	6.2	1967.5
No. 2	6.0	3196.5
No. 3	5.6	3052.5
No. 4	4.0	2749.5
No. 5	3.6	2581.5
No. 6	2.0	1360.0
No. 7	1.8	1008.5
No. 8	2.1	1127.9
No. 9	3.4	2007.5
No. 10	2.1	1318.0
No. 11	2.2	1265.0
No. 12	1.8	987.0
No. 13	2.9	1484.2
No. 14	1.2	881.5
No. 15	0.2	177.5

See Table No. 4 for co-ordinates.

LE No. 7.—*Estimates of canal and basin,* 1883; *table showing mean ordinates, areas, d volumes within the limits of the slopes of canal and basin, and the lines of bottoms of al and lake in* 1883, *including dredged volume.*

Sections.	Mean ordinate.	Area.	Distance between sections.	Quantities.
				Cubic yards.
No. 1	15.1	10,082.0	520	74,997.5
No. 2	19.0	13,058.3	381	162,815.4
No. 3	18.1	11,046.2	492	219,363.0
No. 4	17.3	12,365.0	475	205,822.8
No. 5	20.2	12,968.2	265	137,056.0
No. 6	19.7	13,466.7	372	182,090.7
No. 7	20.4	12,906.5	422	206,078.2
No. 8	17.1	11,853.0	330	148,145.6
No. 9	17.5	12,220.0	232	101,225.8
No. 10	18.0	11,505.2	540	237,152.1
No. 11	17.0	11,039.0	300	125,236.5
No. 12	18.7	10,238.0	304	119,758.6
No. 13	19.6	10,498.5	405	155,482.6
No. 14	21.2	17,166.0	430	166,357.6
No. 15	19.2	16,854.6	439	276,571.6
No. 16	18.5	15,910.0	433	262,686.8
No. 17	18.1	14,738.2	340	192,890.8
No. 18	18.1	7,610.5	658	318,294.2
No. 19	12.6	6,676.0	418	110,509.2
No. 21	11.1	5,855.4	574	127,560.2
No. 23	11.0	5,383.5	766	151,622.6
		0	1,315	107,907.9
Total				3,789,632.7

See Table No. 6 for co-ordinates.

TABLE No. 2.—*Showing fill in inner harbor within the limits of the slopes of canal and basin from 1882 to 1883 (see profiles). In the fractions, the numerator, denotes the distance measured from the shore edge of the slope, the denominator, the fill at that distance on the limits of proposed excavation.*

Sections.	Ordinates and distances.																					
No. 1	1	21	50	100	150	155	200	225	250	280	300	330	350	400	450	455	500	550	600	650		
	1	5.2	5.4	7.9	12.5	12.8	12.6	12.8	14.8	15.2	14.8	13.6	14.8	17.2	20.0	20.0	15.8	11.0	6.2	0		
No. 2	1	50	100	150	200	250	300	350	370	400	410	450	475	500	550	585	600	650	662			
	1	[illegible]	[illegible]	5.2	4.4	3.6	7.4	8.4	9.2	8.4	8.4	9.4	10.2	9.2	9.2	8.6	6.6	1.0	0			
No. 3	1	15	35	65	115	165	215	265	315	365	415	465	515	565	605							
	1	2.4	4.4	2.0	3.4	2.6	3.6	5.0	5.2	5.4	5.0	5.0	4.4	4.0	0							
No. 4	1	20	30	80	130	180	230	280	330	380	430	480	530	580	610	630	660					
	1	2.2	2.6	[illegible]	4.9	3.4	4.2	4.6	5.4	5.4	5.4	5.4	6.2	6.4	6.6	3.8	0					
No. 5	1	50	80	100	150	200	250	300	350	400	450	500	550	585	600	640						
	1	4.0	4.4	4.0	4.6	5.4	5.4	5.0	2.8	4.6	5.6	5.8	6.2	6.8	5.0	0						
No. 6	1	50	100	150	200	250	300	350	400	450	475	500	550	600	605	650	660					
	1	4.9	5.2	4.9	4.2	4.9	5.6	5.6	6.4	6.4	5.8	6.2	7.2	7.6	7.2	1.6	0					
No. 7	1	30	80	130	140	180	230	290	330	380	430	480	530	565	580	620						
	1	2.6	4.8	6.4	6.0	4.6	3.8	5.8	5.8	6.0	6.6	7.0	7.6	7.4	5.2	0						
No. 8	1	20	30	60	90	120	130	160	210	260	310	335	360	410	460	510	560	570				
	1	2.6	4.4	4.9	5.2	5.4	5.2	5.9	6.2	6.4	6.6	7.2	7.4	7.2	7.8	7.8	1.0	0				
No. 9	1	20	50	100	150	200	250	300	350	400	450	500	550	600	610							
	1	2.8	2.6	3.9	4.0	3.8	5.6	6.2	7.2	6.6	7.2	7.0	7.0	1.0	0							
No. 10	1	40	50	100	150	200	225	250	300	350	400	450	500	556	600	605						
	1	4.9	5.4	4.6	5.8	7.0	8.2	8.0	8.2	8.0	7.4	7.2	6.8	6.6	0.6	0						
No. 11	1	40	50	100	150	200	250	300	350	400	450	500	515	550	570							
	1	6.4	6.6	5.2	7.0	7.6	7.9	7.8	8.0	7.6	7.4	7.0	6.8	2.4	0							
No. 12	1	30	80	130	180	230	280	330	380	430	460	480	525									
	1	[illegible]	[illegible]	[illegible]	5.4	5.1	7.8	7.8	7.8	7.4	7.4	5.4	0									
No. 13	1	35	50	100	120	150	200	250	300	350	400	450	490	500	550							
	1	2.8	2.6	1.0	2.4	4.1	5.9	7.6	7.8	8.4	8.4	8.2	7.8	6.4	0							
No. 14	1	25	75	100	125	175	225	275	325	375	425	475	525	575	625	675	725	735	775			
	1	[illegible]	4.6	6.0	4.4	8.1	5.0	5.6	9.5	9.4	8.8	8.0	7.4	6.8	6.3	5.6	5.2	5.1	0			
No. 15	1	25	45	95	145	170	195	245	295	345	370	395	445	495	545	595	645	695	745	777	795	81
	1	2.0	2.2	1.2	5.2	6.1	5.5	6.7	8.8	9.0	9.0	9.4	10.0	10.4	9.2	7.4	7.2	6.5	5.4	4.8	2.4	0
No. 16	1	30	50	100	150	200	225	250	300	325	350	400	450	500	550	600	650	700	750	770	800	81
	1	3.8	3.8	2.0	2.6	2.8	5.8	7.2	8.1	8.5	8.7	9.4	10.2	8.4	8.0	7.4	6.3	5.6	5.2	5.0	1.0	0
No. 17	1	21	50	100	150	175	200	250	300	350	400	450	500	550	600	650	700	728	750	765		
	1	2.4	2.6	2.0	3.2	4.2	7.7	6.5	7.6	9.3	9.3	9.3	8.4	7.4	6.3	5.5	4.8	4.4	1.6	0		
No. 18	1	21	60	110	160	185	210	260	285	310	360	410	460	478	510	520						
	1	2.2	5.6	5.8	5.9	7.6	7.6	7.6	7.6	7.2	6.2	6.0	6.2	6.2	1.6	0						
No. 19	1	5	30	55	105	155	205	255	305	355	405	435	455	475								
	1	4.6	5.7	3.6	6.1	5.4	6.2	6.4	6.4	6.2	6.2	5.6	3.2	0								
No. 21	1	25	45	75	125	175	225	275	325	375	408	428	443									
	1	3.8	3.6	3.2	4.4	3.2	5.4	5.4	5.2	4.8	4.8	2.0	0									
No. 22	1	20	50	70	120	170	220	270	320	370	410	420	450									
	1	2.4	2.4	3.2	3.2	3.2	4.5	5.2	5.0	5.0	4.8	3.6	0									

See Table No. 4 for mean ordinates, maximum ordinates, areas, distances between sections, volumes

Claiborne group of tertiary strata: Clayey green sand marl.....	*Feet.* 229.5 to 231.3	Clear and round; $\frac{1}{16}$ of an inch in diameter and less.	A little in crystals.	Same species as at 171.3.	*Planulina* n. *ampla* Ehr. two species. Do. n. *octenaria* Ehr. Do. n. *cornu* Ehr. *Cristellaria*, sp. undet. 2. Do. n. *arcuata* Williamson. *Lenticulina*, n. discus, Ehr. *Discorbina*, ten species undet. *Rotalia*, two species undet. *Rotalina*, n. Ehrenbergii Bailey. *Globigerina*, sp. undet. Do. n. *helicina*, Carp. *Sphaeroidina*, sp. *Polystomella* n. *craticulata*, Carp. *Glandulina* n. *laevigata*, D. orb. *Strophoconus*, sp. undet. *Polymorphina*, sp. undet. No. 1. *Vaginulina* n. *tenuis*, Ehr. *Textilaria*, 3 species undet.
Do..	231 to 231.3	........do..	Crystals................	......do..................	*Rhizopoda*, *Plagiophrys*, sp. undet. *Haliomma*, n. *oculum*, Ehr. *Foraminifera*, as follows: *Miliola*, n. *ovum*, Ehr. *Gromia*, sp. undet. *Lagena* (*entosolenia*), n. *globosa*, W. Do. n. *squamosa*, W. Do. n. *marginata*, W. *Rotalina*, n. Ehrenbergii Bailey. *Cristellaria*, n. *arcuata*, W. sp. 2. Do. sp. No. 3, undet. Do. sp. No. 4, undet. *Globigerina*, sp. No. 3, undet. *Discorbina*, sp. No. 11, undet. *Bulimina*, sp. undet.
Clay-colored calcareous rock.	231.3	........do..	None....................	Fragments...........	None.
Dark sandy clay, with pebbles.	234 to 236.8	........do..	......do..................	None....................	None.
Clay-colored sand*............	236.8	Clear, sharp, and rounded, some grains spotted with carnelian.	Rare.....................	Fragments very abundant.	*Lagena* (*entosolenia*), n. *marginata*, W. sp. No. 2. *Cornuspira*, sp. undet. *Trochammina gordialis*, Carp. *Spiroloculina*, sp. undet.

* By some mistake Mr. Wilson reports the last specimen as "limestone."

L 4.

REPORT OF H. D. GARDEN, ASSISTANT ENGINEER, UPON LEVEE WORK ON THE FRONT, THIRD DISTRICT.

UNITED STATES ENGINEER OFFICI
Vicksburg, Miss., October 8,

SIR: In compliance with your instructions of the 3d instant, to "prepare a report of levee work on the Tensas Front, for embodiment in the annual r the Commission," I have the honor to submit the following tabulated statem remarks on the levees under my direction in Louisiana:

TABULATED STATEMENT.

Levees, Tensas front, in Louisiana, Third District.

Names of levees.	Average height.	Length of levee.	Contents (completed).	Amou embe yet n to co
		Feet.	*Cubic yards.*	*Cubi*
Upper Providence	6	7,283	46,857.7	......
Hagaman Point	7	1,963	14,305.2	......
Wilton to Raleigh	12.5	23,588	343,087.7	
Raleigh to Willow Point	....	9,648	41,287.7	......
Omega	9	16,310	199,059.7	......
Cabin Teele	6.5	13,621	90,002.2	......
Sparta	6	6,771	39,156.9	......
Delta to Bedford	9	28,287	243,903.3	......
Panther Forest	....	26,380	163,182.0	......
Duffin Break	6.7	10,960	80,246.0	......

Names of levees.	Width of crown.	Front slopes.	Back slopes.	Height of net grades above high-water mark of 1882.	Height or ab grade a water 1
	Feet.			*Feet.*	
Upper Providence	8	3 to 1	3 to 1	1.5	
Hagaman Point	8	3 to 1	3 to 1	1.5	
Wilton to Raleigh	8 and 6	3, 4, and 5 to 1	3 to 1	1.5	
Raleigh to Willow Point	8	3 to 1	3 and 2½ to 1	1.5	....
Omega	8 and 7	3 to 1	3 and 2½ to 1	0.5	
Cabin Teele	8 and 6	3 to 1	3 and 2½ to 1	0.5	
Sparta	8 and 7	3 to 1	3 to 1	1.1	
Delta to Bedford	6	3 to 1	2½ to 1	0.5	
Panther Forest	8, 6, and 3	3, 3½, and 2 to 1	2½, 2 and 1½ to 1	.53	....
Duffin Break	8	3½ to 1	2½ and 2 to 1	.3	

NAME OF LEVEES AND REMARKS.

Upper Providence levee, East Carroll Parish, Louisiana.—About 3 miles ab town of Providence. Work began November, 1882. Completed February, 18

Hagaman Point levee, East Carroll Parish, Louisiana.—About 2½ miles be town of Providence. Work began February, 1883. Completed March, 1883. ing the construction of this work, a temporary protection levee was ordered h taining 2,029$\frac{4}{5}$ cubic yards.

Wilton to Raleigh levee, East Carroll Parish, Louisiana.—Work began on th in October, 1882, and with as large a force as the contractors could collect, pro from each end towards the center, until the suspension on account of the March, 1883, at which time there was a gap of 1½ miles on which very little w been done. The river bank along this front is very low, and the water rising in February it was deemed impossible with the force on hand (between four hundred men) to fill up the gap before the overflow; protection levees were t ordered to connect the new work with the "Old Front levee." The upper pr sustained the pressure of the water and saved all the work above it, but the lo succumbed to the fast rising flood, and the strong current rushing rapidly thro main line swept away 31,552 cubic yards before its destructive effects could be a It has since been found inexpedient, on account of insufficient funds, to conti

L 5.

REPORT OF GEORGE M. HELM, ASSISTANT ENGINEER, UPON LEVEE WORK ON TH YAZOO FRONT, THIRD DISTRICT.

GREENVILLE, MISS., *November* 15, 1883.

SIR: In accordance with your request, the following report of operations under m charge on levee construction on the Yazoo front, third district, in connection with m and profiles of each project of work done by the river commission, together with a p folio profile of survey of levees sent on heretofore, is respectfully submitted.

This survey was commenced by the "Mississippi Levee Board" in March, 1882, a was under your instructions finished from Leota to the Warren County line, Decemb 25, 1882. It covers the entire district of the "Mississippi Levee Board" from Tott Ridge, north of Hushpukna, in Coahoma County, through Bolivar, Washington, a Issaquena Counties, to the Warren County line, a distance of 1,056,200 feet, or 200 miles.

Levees were run with reference to Memphis datum plane, and U. S. P. B. M., and average fall of the river from Hushpukna to Greenville found to be 0.377 foot per m and from Greenville to the Warren County line 0.306 foot per mile. Average fall f upper to lower end of district 0.304 foot. Average height of levees above Green not including Hushpukna and Lake Bolivar crossings, 8.05 feet; average height b Greenville, 6.06 feet; height of Hushpukna levee, 36 feet; height of Lake Bolivar le 24 feet.

The following statement will exhibit the length of levee constructed, amount of embraced in estimates returned to date, and amount of cubic yards to complete with specifications of all work done in your district from October 1, 1882, to Nov 1, 1883:

Names of levees.	Length of levee.	Contents completed.	Amount November 1, 1883, yet necessary to complete.	Width of crown.	Front slopes.	Back slope.	Height of net grade above high-water mark of 1882.	Height of gross or shrinkage grade above high-water of 1882.
	Feet.	*Cubic yards.*	*Cubic yards.*	*Feet.*			*Feet.*	*Feet.*
Riverton levee	9,372	151,663		8	3 and 4 to 1	3 to 1	1.1	3.5
Beulah breaks—1 to 9 inclusive	4,009	27,152		8	3 and 4 to 1	3 to 1	0.4	1.09
Beulah to Riverton enlargement	18,700	66,836		8	3 to 1	3 to 1	1.8	2.15
Beulah to Hughs enlargement	26,610	150,538		8, 1, and 4	3, 4, and 5 to 1	2 and 3 to 1	1.28	{1.60 5.58
Hughs break	1,756	22,882		8	3 to 1	3 to 1	1.4	3.3
Wade break	2,207	50,714		8	4 to 1	3 to 1	1.1	3.4
Clay and Bagot to Rowlands	41,140	96,015	7,283	8	3 and 4 to 1	2 and 3 to 1	1.42	1.72
Rowlands to Jenkins	42,919	156,213		8	3 and 4 to 1	2 and 3 to 1	1.76	2.33
Jenkins to Easton, including Bolivar bayou and Easton break	{14,010							{1.9
	969							3.7
	39	51,287	7,344	8	3 and 3 to 1	2 and 3 to 1	1.53	3.7
Longwood	4,980	75,891		8	4 to 1	3 to 1	3.87	5.93
Longwood protection	2,228	15,978		4 and 5	3 to 1	3 to 1		1.45
Skipwith	69,012	77,660		8	3 and 4 to 1	3 to 1	2.9	3.37
Elleslie	9,975	133,500		8 and 4	4 and 3 to 1	3 to 1	4.08	5.49
Elleslie protection	2,000	2,996		3	2 to 1	2 to 1	.05	1.0
Drainage ditch		218						
Shiloh and new line at Arcadia	{21,135	67,299		3, 4, 6, and				2.3
	4,044			8 to 1	3 to 1	2 and 3 to 1	2	2.2
Magna Vista to Chotard	22,935							2.48
Higgins break	3,265	49,357		4 and 6	3 to 1	2 and 3 to 1	2	3.0
Total	301,305	1,196,199						

[illegible] Greenville Section.

[illegible]

[illegible] unique both in its collocation and in the ma[illegible] high-water mark; and although the ma[illegible] might from its appearance be taken to b[illegible] resemble in color the transition b[illegible] while below that level lignite grains a[illegible] seems to justify the conclusion that noall[illegible] older material lies at or near the surface[illegible]

[illegible] strata are also here found at an unu[illegible] have been struck in any of the borings, [illegible] a ridge analogous to the "Dogwood R[illegible] Ridge, and runs from opposite Helena [illegible] the Yazoo bottom.

[illegible] by the augur from the Greenville borin[illegible] in appearance with that from the Chocta[illegible] while somewhat different from those of t[illegible] same general character. From the known [illegible] be presumed that higher strata are met [illegible] beneath the bottom as well as on th[illegible]

[illegible]

[Descripti]on of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic [fossils.]
	Feet.				
[...] non-calcareous silt, [...]crated vegetable mat[ter, alternati]ng in the proportions [of sand a]nd clay every few feet.	0. to 9.6	Rounded and clear, with some grains of jasper and chert.	A little	None	None.
[...]	9.6 to 15.6	Clear, small, and sharp	do	do	Do.
[...] sand, slightly coherent.	15.6 to 29	Mostly clear, with some grains of milky quartz and chert.	A good deal	do	Do.
[...]ish blue clay	29 to 30	Small, clear, and sharp	None	do	Do.
[...]yish yellow sand, slightly co[he]rent.	30 to 42.9	Well rounded, clear, and variegated	A little	do	Do.
[Por]t Hudson:					
Loose sand with grains of lignite	54.8	Clear, rounded, and sharp; some grains spotted with carnelian.	Abundant	A little	None.
Fine brownish silt, darker below, with lignite in grains.	56 to 82	Rounded, clear, and red spotted	A good deal	In brown and green crystals.	Do.
Bluish gray clay	82 to 84	Rounded and sharp, clear and reddish.	do	None	Do.
Clayey silt of a terra-cotta color; abundant lignite grains.	100.5 to 101	do	Abundant	None	Do.
Grayish yellow sand; vegetable matter abundant.	101 to 103.2	Rounded, clear, and reddish	do	A good deal	Do.
Brownish clay	103.2 to 104	Small, clear, and sharp	None	None	Do.
Coarse sand with chert pebbles	109 to 127.6	Variegated, round, and sharp	do	do	Do.
Black lignite	127 to 131.5	None	do	do	Do.
Whitish blue sandy clay	131.5 to 170	Clear and sharp	A good deal	A little	Do.
Fine yellowish clayey sand	170 to 191	Clear and variegated; rounded	None	None	Do.
Gray sand with clayey streaks	191 to 247	Clear and smoky; well rounded	do	do	Do.
Blackish brown clay	247 to 248	Small and sharp, clear and yellow	do	A little	*Navicula*, n. *sigma*, Ehr. *Navicula*, sp. undet.

For comparison with the above, an examination was made of a typical specimen of "buckshot" clay collected in Issaquena County, Mississippi; an undoubted Port Hudson locality.

Description of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
Stiff blue clay with ferruginous concretions, or "buckshot;" lignite grains abundant.	10 inches from the surface.	Mostly clear; some grains red; from $\frac{1}{700}$ to $\frac{1}{5000}$ of an inch in diameter; the larger grains round, the smaller sharp.	None	None	None.

A. Method of checking Sloughing.

B. Method of stopping Crayfish Borings.

C-C[1] Revetment of Ends of Broken Levee.
Scale 1 inch = 15 feet.

[illegible]gles from the known sides at lower portion of work to check on [illegible] [illegible] river. These points were then plotted on protractor sheets and transferred [illegible] [illegible] already made of old points, and fitted at upper end by bench-marks [illegible] [illegible] purpose.

[illegible] map work was done by Messrs. Amelung and Ritchie in conjunction. The plac[ing] and location of triangulation points and ranges was done by Mr. Amelung, the sounding[s] by Mr. Ritchie, and the levels by Mr. Pattison, who also acted as recorder for the oth[er] gentlemen. To their exertions is principally due the completion of the survey bef[ore] the rise of river, which began the day after the work closed.

The quarter-boat, in tow of the launch Nellie, returned to Wilson's Point and [re]ported to Mr. Hider for duty on the 30th.

Respectfully submitted.

WM. T. BLUNT,
United States Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

APPENDIX M.

REPORT OF MAJOR AMOS STICKNEY, CORPS OF ENGINEERS, UPON OPERATIONS IN T[HE] FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
No. 3 SOUTH RAMPART STREET,
New Orleans, La., November 20, 1883.

SIR: I have the honor to report as follows on the several works in my charge un[der] the supervision of the commission, from December 1, 1882, to October 31, 1883.

LEVEES.

Since December 1, 1882, work on levees has continued with some interruption by hi[gh] water in the Mississippi, which in some cases caused a total suspension of work and [ne]cessitated the extension of the time for completion of all unfinished levees. Progress [has] been much slower than was anticipated when contracts were made. This was due t[o] scarcity of labor last season, and unusual amount of malarial fevers this season, and [the] bad management of contractors. Repeated notices have been sent to the different co[n]tractors whose work progressed slowly with small forces to increase the number of lab[orers] [illegible] but these notices seem to have had no effect. Up to date six levees ha[ve] been [illegible] and accepted, leaving five more unfinished. Two of these will probabl[y] be [illegible] by the end of the year, and the others, it is hoped, before the floods. The[re] is [illegible] with the approach of cool weather of the contractors largely increasing th[eir] forces and making better progress.

SURVEY OF UNLEVEED FRONT.

[illegible] surveys have been made at several localities along the line of levees in th[e] [illegible] has been made yet for construction of the levees. Portions [illegible] have not been [illegible], and others have proved to be too close [illegible] With a view [illegible] the line of levees to make them continuous, and [illegible] not yet surveyed, parties are now being organized. The following rep[ort] [illegible] assistant engineer in general charge of levees, gives the details:

NEW ORLEANS, LA., *November* 5, 1883.

SIR: I have the honor to submit the following report on the "construction and rep[air] [illegible] fourth district," from December 1, 1882, to October 31, 1883, giving each lev[ee] in detail.

TENSAS FRONT.

[illegible] to Buck Ridge near Point Pleasant. Total length of embankme[nt] [illegible] Computed contents [illegible] cubic yards. Slopes, 2 and 3 to 1. Crow[n] [illegible] On December 1 the contractor was at work with a small force, bei[ng] [illegible] that his work would not exceed [illegible] cubic yards; but on Dece[m]ber [illegible] was notified that his work would be increased, and he was directed to emp[loy] [illegible] labor. This he failed to do, and although an embankment sufficient to re[sist] the water was constructed, the levee was not completed before the rising river ca[me] [illegible] Work was resumed on the subsidence of high water, and the levee was co[m]pleted and accepted August 6, 1883.

67

UNLEVEED FRONTS.

	Estimated length.	Estimated cubic yards.
	Feet.	
Castleman's to New Carthage	50,000	410,000
Bougière	23,400	637,000
Black Hawk to Red River	88,500	....

Timber felled on all levee lines, 260 acres.
Total length of levees under contract, 51 miles, 2,065 feet.
Length constructed to October 31, 45 miles, 3,936 feet.
Remaining to build, 5 miles, 3,409 feet.

	Feet.
Total contents of levees as computed	1,764,291.04
In embankment October 31	1,257,366.01
Remaining to place in embankment	506,925.03

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

IMPROVING MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA.

No work has been done since the transfer of this work to me by Capt. A. M. Miller, Corps of Engineers, U. S. A. It had been my expectation to have an examination made of this locality during low water, for the purpose of preparing a project for work, but the unusual sickliness of the season has so crippled my force of assistants that nothing has been done. The old survey shows the principal features of the locality, and I expect to base a project upon that survey. A recent general view of the banks obtained in passing on a steamer shows that the caving of the banks continues as before, but only to a small extent in Giles Bend, the worst caving being in Marengo Bend and down toward Waverly Point. The danger to Natchez Harbor is not immediate, but works for bank protection will be required to prevent the working down of the bend above Natchez.

IMPROVING MOUTH OF RED RIVER.

At the date of my last annual report to the Commission work in old river and at the mouth of Red River was suspended, as high water made it no longer necessary for navigation.

[illegible] of August 17, 1883, to the president of the Commission, I recommended to the Commission that, if necessary to keep open navigation during low water, the same [illegible] as heretofore, that is, by moving a stern-wheel steamboat attached to [illegible] backward and forward over the shoal places to stir up the mud, so that the cur[illegible] channel, and to use a dredge-boat for cutting a channel through the bar [illegible]. This having been approved by the Commission, steps were [illegible] 1883, to procure the necessary plant.

[illegible] have been at work by September 3, 1883, but on account of [illegible] of one of the tugs after starting from New Orleans, and the sink[illegible] the supply of coal, actual operations were not commenced [illegible] was 9 feet of water on the outer bar and 5 [illegible] River, and it was thought that a channel [illegible] with great rapidity, and the banks, [illegible] almost completely closing the water-way [illegible]. The consequence of this was an immediate draining of Lower [illegible] a point about a mile above the foot of Turnbull's [illegible] aground [illegible] them having scarcely any water around [illegible].

[illegible] October 11 and [illegible] at one place a width of about 3 feet, with [illegible] which was all that remained of the river. This sliding in of the

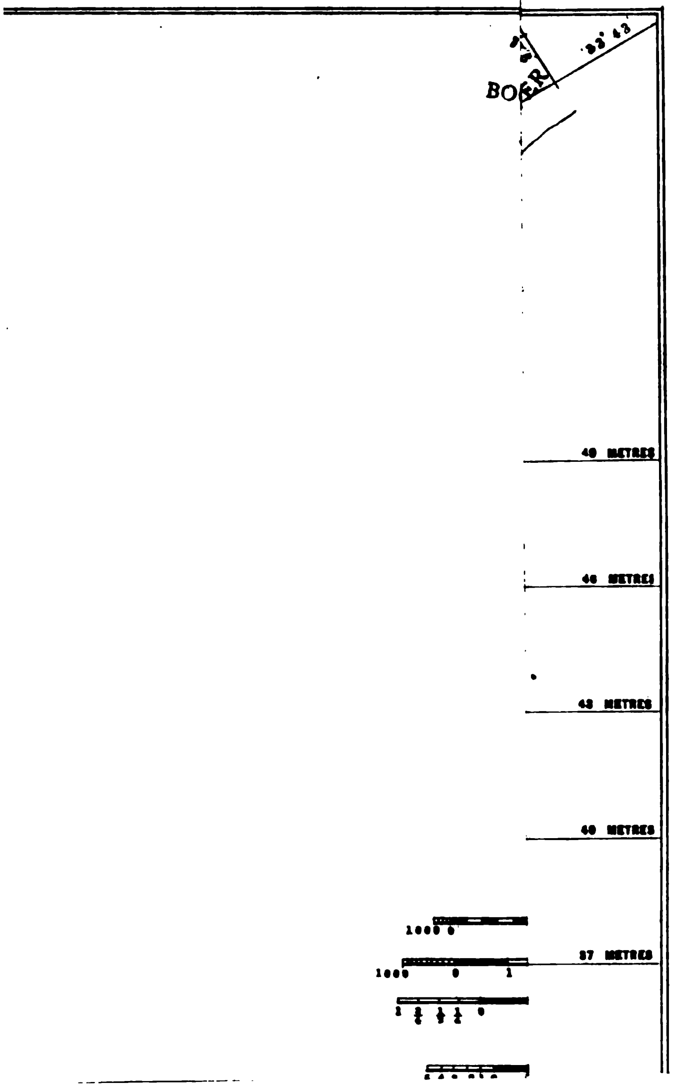
banks has occurred at each low-water season for a number of years, but never before to the extent of this year.

Some harsh comments have been made, as in previous years, with regard to the failure of the plant to keep a navigable channel, but such comments must certainly have emanated from persons much interested in keeping navigation open, but ignorant of the nature, or extent of the cause, which operated to close the channel. It has never been claimed that the plant used could do anything more than help the current in deepening the shoal places, when the water was low enough for the action of the tug wheels to be felt on the bottom and the volume of water and current strong enough to carry off the material stirred up. The dams formed by the sliding in of hundreds of feet of the river banks not only cut off the necessary water to float the boats, but stopped the current necessary to carry away any material that might have been stirred up. This peculiar sliding in of the banks in this locality has, I believe, never been satisfactorily explained. Upon my recent visit I made a special investigation of the matter, and I believe I have discovered the cause of the instability of the banks to be the presence of water back of the banks, whose surface is at a considerable elevation above the river. When the river falls rapidly this back water, acting under a considerable head, forces its way under the banks, converting the lower strata into a semi-liquid material which will not stand under a slope of 1 in 20, or even flatter. I believe there was not a single instance of sliding bank behind which I did not find either standing water or pools where water had recently been. The natural drains for this back water are each year more and more obstructed by the deposit of sediment from overflows, the obstruction increasing more rapidly near the river banks. As a result of this the pond water is held at a higher level, and when the river is low forces its way through the soil under greater head.

The steamboat and tugs commenced work September 7, and were compelled to stop September 25. They resumed work on October 17, and on November 10 were ordered to return to New Orleans, there being a navigable channel 8 feet deep through Old River. The dredge commenced work on the outer bar September 8, and worked continuously until October 22, when she was moved up to the gut. On the 10th of November she was laid off. I am at present engaged upon a plan for the permanent improvement of this locality, which I hope to present to the Commission in a short time. In December, 1882, an assistant engineer was sent to make some surveys of Old River in order to obtain data for estimates and project for placing a sill across old river, with dikes across the valley to check the enlargement of the passage into the Atchafalaya River. This was completed early in February, and estimates were submitted to the Commission March 20, 1883. The Commission decided to postpone action on this. Upon my recommendation for a resurvey of the old river, which was approved by the Commission, a party was started from New Orleans, June 5, and work commenced a few days afterwards, but sickness and unfavorable weather at times almost suspended operations. The survey is still in progress, and it is hoped that the present cool weather will enable the party to complete it soon. The following report of the assistant engineer in charge gives the details:

RED RIVER LANDING, *October* 31, 1883.

MAJOR: I have the honor to report to you the amount of work accomplished on the survey of the mouth of Red River and vicinity since the 7th of June, when I arrived with a portion of my party, which was not complete until the arrival of the steamer on the 22d of June. The survey of the Mississippi, including both banks, is finished from below Red River Landing to Carr's Point, by means of a shore line on the left bank and distances carefully measured to the top of the bank, so as to show the bank accurately, and a note of the stage of water and its line at the edge. The opposite bank is located by a series of angles taken on flag stations placed on all points and bends, so as to define the line of the top of the bank correctly. The sides of triangulation on the right bank forming the bases are never less than half a mile in length, and every base has been carefully measured and checked with a steel-tape measure. Observations of the true meridian have been taken on this base line. A traverse line for the immediate topography has been run on the levee from half a mile below River Landing to section No. 12, on Atchafalaya River. Cross-sections Nos. 2, 4, 8, and 12 of the Atchafalaya have been relocated, sounded, plotted, and sent into the office. Likewise in the lower old river, cross-sections F, G, I, Z, X, also D, V, and at the mouth, near the Mississippi. These sections require to be extended back on high ground on the right of the Atchafalaya, and on the Turnbull Island side of Old River, now that the water is low enough to make it practicable to do so. Eight sections have been taken on the upper old river at right angles to the bed of the river extending across all the chutes to the high ground on either side, and the with approximate location on the map of 1879 have been sent to the office. A section of the low-water discharge of Red River have been taken 1,000 feet above the


40 METRES
46 METRES
43 METRES
40 METRES
37 METRES

Tabulated results of discharge measurements.

Date.	Gauge.	Water width.	Water area.	Datum area.	Mean velocity per second.	C
1883.			*Sq. feet.*	*Sq. feet.**	*Feet.*	
January 27	4.609	2,289	147,596	137,236	2.830	
January 30	4.970	2,290	148,642	137,448	2.994	
January 31	5.310	2,290	149,784	137,766	3.008	
February 1	5.630	2,291	152,046	139,061	3.028	
February 2	6.170	2,292	153,062	139,181	3.249	
February 5	7.634	2,300	157,266	139,826	3.820	
February 7	8.494	2,329	159,190	139,228	4.133	
February 8	8.738	2,340	159,668	139,614	4.070	
February 9	8.989	2,342	160,362	139,837	4.198	
February 10	9.230	2,348	161,014	140,051	4.219	
February 13	9.485	2,355	162,122	140,517	4.190	
February 15	9.915	2,355	161,230	138,612	4.269	
February 17	10.385	2,360	162,212	138,566	4.705	
February 19	10.980	2,362	162,736	137,501	4.823	
February 20	11.075	2,364	163,014	137,424	4.833	
February 21	11.165	2,366	162,862	137,107	4.962	
February 22	11,340	2,420	164,376	138,275	4.922	
February 23	11.680	2,518	165,012	137,506	5.172	
February 28	12.151	2,520	165,492	136,892	5.143	
March 1	12.330	2,546	164,848	135,733	5.159	
March 2	12.377	2,546	164,926	136,151	5.268	
March 3	12.298	2,550	165,486	136,627	5.338	
March 5	12.490	2,555	165,976	137,301	5.467	
March 7	12.685	2,560	163,498	133,140	5.551	
March 9	12.952	2,567	164,686	133,891	5,688	
March 12	12.785	2,567	158,542	128,171	5.631	
March 13	12.875	2,567	158,623	128,240	5.571	
March 14	12.940	2,567	160,700	130,022	5.670	
March 15	13.045	2,567	161,146	130,152	5.743	
March 16	13.102	2,567	162,386	131,267	5.670	
March 17	13.175	2,567	162,664	131,384	5.644	
March 19	13.317	2,567	162,426	131,570	5.702	
March 20	13.492	2,567	162,838	131,560	5.818	
March 21	13.452	2,567	164,040	132,640	5.834	
March 22	13.300	2,567	163,658	132,594	5.837	
March 23	13.468	2,567	163,280	132,000	5.849	
March 24	13.910	2,567	164,422	132,170	5.854	
March 26	13.991	2,567	159,410	126,802	6.218	
March 28	14.120	2,567	159,726	126,832	6.199	
March 29	14.264	2,567	160,132	126,879	6.154	
March 30	14.560	2,567	164,784	131,055	6.107	1,
March 31	14.675	2,567	165,070	131,087	6.123	1,
April 2	14.839	2,567	167,010	132,141	6.220	1,
April 3	14.945	2,568	167,244	132,142	6.175	1,
April 4	15.007	2,568	170,620	135,452	6.066	1,
April 5	15.032	2,568	171,810	136,871	6.078	1,
April 6	15.133	2,568	173,082	137,923	5.970	1,
April 7	15.388	2,568	173,487	137,772	6.219	1,
April 9	15.465	2,568	174,694	138,428	5.982	1,
April 10	15.260	2,568	174,195	138,475	6.005	1,
April 11	15.123	2,568	175,870	141,030	5.823	1,
April 12	15.103	2,568	178,080	142,814	5.800	1,
April 14	15.061	2,568	183,272	147,936	5.621	1,
April 16	14.808	2,568	179,526	144,930	5.583	1,
April 17	14.689	2,567	184,212	149,886	5.554	1,
April 18	14.610	2,567	184,123	149,972	5.538	1,
April 19	14.564	2,567	181,130	146,998	5.507	
April 20	14.580	2,567	182,189	148,021	5.469	
April 21	14.500	2.567	180,716	146,607	5.315	
April 23	14.487	2,567	180,689	146,609	5.397	
April 24	14.420	2,567	179,468	145,724	5.336	
April 25	14.355	2,567	179,407	145,795	5.346	
April 26	14.223	2,567	180,031	147,023	5.313	
April 27	14.300	2,567	180,123	146,946	5.320	
April 28	14,201	2,567	179,579	146,619	5.414	
April 30	14.213	2,567	178,714	145,655	5.361	
May 1	14.238	2,567	178,608	145,378	5.260	
May 2	14.234	2,567	178,608	145,378	5.258	
May 3	14.245	2,567	179,716	146,338	5.263	
May 4	14.190	2,567	179,569	146,332	5.256	
May 5	14.268	2,567	179,774	146,337	5.255	
May 7	14.130	2,567	178,388	145,251	5.267	
May 8	14.014	2,567	178,192	145,353	[illegible]	

* Below zero of Carrollton gauge.

Tabulated results of discharge measurements—Continued.

Date.	Gauge.	Water width.	Water area.	Datum area.	Mean velocity per second.	Discharge per second.
			Sq. feet.	Sq. feet.	Feet.	Cub. feet.
	14.076	2,567	176,076	143,165	5.323	936,487
	14.114	2,567	176,232	143,224	5.395	950,759
	14.151	2,567	176,968	143,560	5.285	935,237
	14.076	2,567	176,788	143,564	5.364	948,441
	14.138	2,567	174,048	149,930	5.363	933,382
	14.003	2,567	174,190	141,431	5.344	930,617
	14.085	2,567	174,394	142,985	5.320	929,697
	14.082	2,567	174,991	142,201	5.243	917,341
	14.171	2,567	175,185	142,174	5.168	907,610
	14.206	2,567	175,278	142,169	5.180	908,054
	14.144	2,567	178,080	145,181	5.115	911,026
	14.058	2,567	177,852	145,174	5.206	916,277
	13.948	2,567	181,829	147,465	5.006	910,271
	13.797	2,567	181,430	149,154	5.020	910,977
	13.719	2,567	182,852	150,728	4.947	904,655
	13.854	2,567	183,190	150,719	4.958	908,261
	13.585	2,567	181,256	149,424	4.928	893,233
	13.688	2,567	181,512	149,423	4.867	883,564
	13.686	2,567	183,050	151,182	4.829	883,848
	13.728	2,561	183,432	151,461	4.816	883,430
	13.625	2,467	180,657	149,059	4.853	876,705
	13.507	2,467	180,379	149,072	4.802	864,043
	13.475	2,467	178,299	147,949	4.941	881,062
	13.484	2,467	182,372	151,006	4.813	877,793
	13.436	2,467	182,257	151,010	4.785	873,108
	13.328	2,467	181,707	151,150	4.816	875,085
	13.316	2,467	181,607	151,050	4.741	861,535
	13.288	2,467	181,645	151,154	4.729	859,046
	13.178	2,417	183,510	153,391	4.714	865,049
	13.135	2,417	183,494	153,474	4.660	855,025
	13.076	2,417	183,586	153,680	4.644	852,517
	13.030	2,417	183,471	153,567	4.654	854,066
	12.934	2,417	183,854	153,969	4.700	862,242
	12.900	2,417	183,276	153,869	4.618	846,443
	12.777	2,417	182,130	152,776	4.557	830,027
	12.765	2,417	182,117	152,790	4.596	837,076
	12.705	2,417	180,701	151,627	4.549	822,081
	12.632	2,417	180,534	151,526	4.573	825,601
	12.640	2,417	180,011	150,973	4.573	823,473
	12.454	2,417	179,615	150,998	4.582	821,731
	12.535	2,417	179,034	150,530	4.565	817,328
	12.552	2,417	179,110	150,644	4.627	828,857
	12.496	2,417	180,465	151,936	4.591	828,430
	12.443	2,417	180,344	151,935	4.605	830,559
	12.541	2,392	184,820	157,058	4.572	845,987
	12.554	2,392	[illegible]	157,027	4.498	831,456
	12.522	2,392	[illegible]	153,932	4.582	831,545
	12.462	2,392	181,502	154,143	4.597	[illegible]
	12.374	2,392	181,282	152,902	4.510	[illegible]
	12.450	2,392	181,492	152,903	4.462	[illegible]
	12.426	2,392	181,396	152,901	4.548	[illegible]
	12.480	2,392	180,871	152,296	4.449	[illegible]
	12.500	2,392	180,871	152,300	[illegible]	[illegible]
	12.540	2,397	179,840	151,156	[illegible]	[illegible]
	12.590	2,397	181,136	152,260	[illegible]	[illegible]
	12.559	2,397	181,020	152,260	[illegible]	[illegible]
	12.565	[illegible]	182,900	154,411	[illegible]	[illegible]
	12.455	[illegible]	182,418	154,110	[illegible]	[illegible]
	12.455	2,392	182,428	154,120	[illegible]	[illegible]
	12.350	2,392	181,240	152,992	[illegible]	[illegible]
	12.345	2,392	181,240	152,992	[illegible]	[illegible]
	12.280	2,392	180,562	152,572	[illegible]	[illegible]
	11.700	2,397	179,302	152,875	[illegible]	[illegible]
	11.455	2,397	[illegible]	152,540	[illegible]	[illegible]
	11.150	[illegible]	[illegible]	150,652	[illegible]	[illegible]
	9.847	[illegible]	[illegible]	150,014	[illegible]	[illegible]
	8.520	[illegible]	[illegible]	148,842	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	148,195	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX F, PLATE 1.

wheel that it is hoped a more favorable shape of wharf and thorough
ug scouring after each high water will prove an effectual remedy. On
following letter was addressed to Mr. Kirk, in charge of the wharves
received from him:

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 31, 1883.

SIR: I desire to call your attention to a method of preventing the caving of bank and consequent destruction of wharves along the river front in third district. The Board of Engineers, of which I was a member, and which assembled in this city in the fall of 1881, recommended in their report (as one of the means that might be tried to prevent this caving) the washing out of the high-water deposit under the wharves by turning the wheel of a tug, so placed as to send a current in the proper way. This, I am informed, was tried to a certain extent last summer with very satisfactory results. As this is a matter of very considerable importance to you in the maintenance of your wharves, I write to ask you to give the plan a more systematic and thorough trial. As the water is now falling, it would be well to commence as soon as possible, before the deposit begins to slide. If this proves to work satisfactorily, all wharves built in future could be so planned as to admit of the proper placing of the tug, and the annual cost of the work would be small. If you conclude to make the trial I would like to have one of my assistants make measurements to note the results, and to give you any assistance that he could with reference to determining the proper points for scouring.

Very respectfully, your obedient servant,

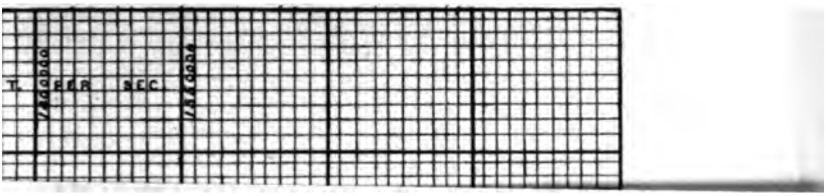
AMOS STICKNEY,
Major of Engineers, U. S. A.

Mr. GEORGE H. KIRK,
New Orleans, La.

In my letter of September 16, 1882, to the Commission, submitting project for improvement of New Orleans Harbor, I called attention to the fact that at other parts of the harbor work would probably be necessary, and that the experience gained and results arrived at in Carrollton Bend would be a guide for the extension of the work. During the past summer very extensive caving of the bank has occurred in the Gouldsborough Bend, and above, on the right bank of the river, the extensive wharf and a part of the large depot building of the Texas Pacific Railroad sunk into the river. The commercial importance of this part of the harbor is rapidly increasing, as shown in the accompanying letter of Mr. E. B. Wheelock, president of the New Orleans Pacific Railway Company, and report of Assistant Engineer W. G. Price. To thoroughly protect the right bank will require a great deal of work, which should cover both bends and perhaps the straight reach between, as shown in accompanying sketch.

NEW ORLEANS PACIFIC RAILWAY COMPANY,
PRESIDENT'S OFFICE,
New Orleans, La., November 17, 1883.

DEAR SIR: In connection with your present important labors in the neighborhood of New Orleans, I beg leave to call your attention to the condition of the bend from Westwego to Algiers, opposite the first district of New Orleans. This bend is rapidly becoming one of the most important portions of the harbor of New Orleans. The Morgan Railroad, managed by the Southern Pacific, and the Texas and Pacific Railway, now operating the property and franchises of the New Orleans Pacific, have costly and needful termini at this point, where facilities must exist for handling the commerce of the Southwest and West, including the Pacific slope. Wharves and transfer facilities have already been built at lavish expense, and more are needed. Besides the railways there are such important enterprises begun on the same shore, as the terminal facilities of the barge companies, compresses and warehouses for cotton, grain elevators, cotton-seed mills and storehouses, and wharves for other purposes. At the upper end of the bend opposite Louisiana avenue there is Harvey's Canal, connecting with the network of navigation through the Bayou Barataria. These great and constantly increasing interests of commerce and navigation require immediate protection. It is a case of urgency included beyond doubt in the protection of commerce and navigation by the National Government. If the river be controlled at that point, the depots, tracks, inclines, wharves, compresses and elevators designed for the trade of half of the continent will be secure and useful. If the river be at this point not controlled the whole machinery of commercial intercourse above detailed is put in constant jeopardy, its development arrested, and its very existence made a matter of doubt. The remedy for this evil does not seem difficult. It cannot be found in private enterprise. It is not within the jurisdiction or duty of any single riparian proprietor. It would seem to be easily found in the scope of the



T. PER SEC.

reaching to with 50 feet of the deep-water end of the mattress. The dike will consist of willow brush d stone. The brush will be woven in thicknesses of 4 or 5 feet and sunk one on ano..er till a thickness of 20 feet is reached. In this bend a dike 20 feet high will carry the bank out horizontally about 60 feet. The current, passing a dike and moving in a line tangent to the curve above, will strike the bank again in about 750 feet, where another dike would have to be constructed. As the bend is somewhat irregular, the dikes would have to be nearer together at some places and farther apart at others.

The mattress under the dike would cost, at 4.42 cents per square foot	$1,547
The dike, at 4.97 cents per cubic foot, would cost	8,946
Making a total cost of mattress and dike	10,493

I have estimated stone to cost $3 per cubic yard, loose measurement, and the dike to contain 5.1 pounds of stone, weighed in water, per cubic foot, over the amount necessary, to overcome the buoyancy of the brush. This weight would be increased by the sand and silt which would collect.

COST OF THE IMPROVEMENT.

FIRST SECTION.

Length of section ... feet	20,300
Cost to protect with mattress	$314,000
Cost to protect with dikes, 750 feet apart	294,000

SECOND SECTION.

Length of section ... feet	6,540
Cost to protect with mattress	$101,000
Cost to protect with dikes, 1,635 feet apart	42,000

THIRD SECTION.

Length of section ... feet	13,600
Cost to protect with mattress	$210,000
Cost to protect with dikes, 750 feet apart	189,000

The entire third section is a caving bank, and if not protected it will in time cut away Algiers, and change the whole front on the opposite side of the river.

Respectfully submitted.

W. G. PRICE,
United States Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

The following is a financial statement of the different works in my charge:

CONSTRUCTION AND REPAIR OF LEVEES, FOURTH DISTRICT.

	Atchafalaya front.	Tensas front.
Allotted	$110,000 00	$426,160 00
Drawn	100,000 00	426,160 00
On hand, Assistant Treasurer, New Orleans, October 31, 1883		174,529 19
Expended to October 31, 1883	102,947 22	251,630 81

Balance, December 1, 1882	$44,966 98
Received since	476,160 00
	521,126 98
Expended to October 31, 1883	349,545 01
Balance on hand, October 31, 1883	171,581 97
Disbursements since December 1, 1882:	
Transportation	1,949 97
Miscellaneous	9,634 59
Inspection of contract work, salaries	$11,720 50
Contract work on levees and protection during high water	326,239 95
Total since December 1, 1882	349,545 01

PLATE III

APPENDIX G.

IMPROVING MISSISSIPPI RIVER—OBSERVATIONS AT CARROLLTON, LOUISIAN

Allotment		$3,
Drawn		3,
Expended		3,
Balance December 1, 1882		3,
Expended to October 31, 1883		3,
Disbursements since December 1, 1882:		
Telegram	$0 72	
Storage	6 00	
Stationery	10 93	
Lumber	12 39	
Coal	134 15	
Material	187 63	
Transportation	220 60	
Hire of launch	300 00	
Services	2, 127 58	
		3, 0

MISSISSIPPI RIVER COMMISSION—OBSERVATIONS AT CARROLLTON, LOUISIAN

Allotted		$1, 5
Expended		1, 4
Balance on hand October 31, 1883		
Disbursements since December 1, 1882:		
Telegrams	$0 75	
Transportation	15 00	
Material	41 98	
Fuel	72 55	
Service	1, 314 33	
		1, 4

CLOSING BONNET CARRÉ CREVASSE.

Allotted	$15,
Drawn	15,
Expended since December 1, 1882, contract work	15,

HARBOR AT NEW ORLEANS, LOUISIANA.

In Treasury Department, Washington, July 1, 1882	$144, 525 90	
On hand, Assistant Treasurer, New Orleans, July 1, 1882	3, 267 91	
In hands of Assistant Engineer, October 31, 1883	100 00	
		$147,
Expended since July 1, 1882		8,
Balance on hand December 1, 1882	2, 055 79	
Expended since	7, 632 89	
Balance due from appropriation	5, 577 10	
Disbursements since December 1, 1882:		
Miscellaneous	506 97	
Material	453 88	
Surveys	145 14	
Service at the works	1, 966 06	
Office expenses, &c	570 93	
Plant	3, 989 91	
		7,
First cost of plant now employed		30,

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers, U.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

APPENDIX G , PLATE V.

ings, which he inclines to consider as the result of imperfect development in consequ of the influx of fresh water. At the early time at which these, the equivalents of Claiborne beds of Alabama, were formed, the continental drainage had its mouth a Cairo, and the Mississippi of to-day had not yet become the one great outlet, the souri having no existence. A gradual upheaval, prevalently from the eastward, shallowing a part of the great Mississippi embayment, so as to convert its margin swamps, intersected by occasional estuaries. Such continued to be the state of thi middle tertiary times over much of the States of Mississippi and Louisiana. Ye find in the intercalated marl the largest and finest fossils; moreover, as a matter of there *are* fragments of large fossils in several instances—*e. g.*, *Venericardia plani Atletha Tuomeyi*, *Monoceros vetustus*, and others. As a rule such large fossils wou driven out of the way by the pipe in its descent, or ground to fragments. The sma and especially those combining hardness with smallness, would be the ones that auger would leave comparatively uninjured, such as *pleurotomas*, *naticas*, *&c.*

Such as they are, however, these fossils overwhelmingly demonstrate the close co spondence of the beds penetrated at Helena and Choctaw Bar (whose *facies* is altog identical) with the lower portion of the Claiborne beds of Alabama; perhaps most with those older ones, which Dr. Eugene A. Smith, State geologist of Alabama, has examined at and near Wood's Bluff, Alabama, and which rest directly upon the old nitic and flatwoods clays. This is obviously the position of the Helena marl bed, he clays found in the bottom boring, No. 1, at 162.3 feet and lower, are absolut distinguishable from those of the Memphis boring. These facts agree again wi fact that, since the strike of the Claiborne strata observed in Mississippi is about northwest (not due west, as inferred by Mr. Wilson from the older geological m Mississippi), their dip must be correspondingly a south-southwesterly one, from phis toward Helena.

The difference of nearly 150 feet between the levels at which the tertiary strata been reached in the bluff and in the bottom boring at Helena, not quite two miles a affords a measure of the energy of the erosion effected by the gravel-charged floo the quaternary epoch.

BOTTOM BORINGS.

In all the deeper bottom borings, save one (viz: No. 2, Lake Providence), thre tinct formations have been penetrated, viz, the river alluvium or its equivalents in the equivalents of the Port Hudson beds, and the eocene tertiary strata.

Much speculation has been indulged in heretofore as to the average depth of the vial deposits of the Mississippi, and the results of my observations in the Delta, w seemed to indicate that the deposits of the modern river are comparatively shallow there, have been repeatedly called in question. The present investigation throws m light on this subject, and likewise rectifies the interpretation of the age of the "b gravel," which has long been known to underlie the great bottom, but was by m conjectured to be, in the main, the representative of the "orange sand" of the upl Mr. Wilson correctly concludes, from the constant occurrence through these grav lignite grains or "wash," that they are not an equivalent of the orange sand, whi always singularly free from any oxidizable matter. The microscopic examination roborates the importance of the lignite grains, and associates them with grains of c lian, and clear quartz spotted with carnelian as characteristics of the Port Hudson to which group the great beds of gravelly sand with the overlying finer sand accordingly referred. On the other hand the same examination shows the veg remains in the alluvium to be merely macerated, or slightly carbonized, detecti other fossils at all.

It is not altogether easy to see why this should be so, and why a few remains of lets or wood fibers, and rarely even these, should be all that remain of the multit objects that the great river has an opportunity of carrying off in its long course, espe at high stages of water. The only reasonable explanation seems to be that the tri ing effect of the sharp sand, with the rapid eddying motion of the river, tends to de by mechanical attrition, all but the toughest material and such large fossils as lo cannot but be presumed that in the back or slack-water deposits of to-day some o many organisms of the cypress swamps must be preserved; but no such material has under our examination. On the whole, a person habitually familiar with the depo the river will rarely fail to recognize them. Moreover, they are all, even to the sand characterized by a very frequent alternation of materials, due to the alternate in deposits from different sources at different seasons of the same year, so that a close o may in many cases identify the materials deposited by floods derived from different such as the Arkansas on the one hand, and the Red River on the other. On the as great a thickness as 20, or even 15 feet, of uniform and unquestionably alluvi

of to-day will rarely be seen, even 10 feet being unusual, and from a few inches 3 feet the most common range.

this point of view, the great sand bed of boring No. 1, at Helena, as well as those eneath the unquestioned alluvium in the Choctaw Bar borings, and in No. 1 of rovidence reaches (Mayersville), presented a doubtful point, these sands being re-ly uniform in their nature and appearance, not only at different depths in the same , but even on comparison of those from different borings. The fact that in all ases the massive sand-beds show both the lignite grains and those of quartz spot-h carnelian, which they have in common, not only with each other, but with the "buckshot clay" of known Port Hudson age, of which an authentic sample was tely in my possession,* is sufficient, in the absence of fossils, to cause them all ferred to the Port Hudson epoch. It is a curious fact that this buckshot clay, is so abundant in the back lands of the bottom, happened not to form the surface point where borings were made, unless it be at Greenville. Stiff clay soils were ral cases found at the surface, but these were underlaid by the undoubted river m.

Greenville boring is unique, in that it was made at a point in the bottom appar-bove high-water mark, and that coincident with this the red and spotted quartz with lignite were found in the sand within a few feet of the surface. No micro-organisms were found in the surface soil, but even that is unlike the river allu- In other words, it seems as if at Greenville the older (Port Hudson) materials t the surface near the river bank, as some distance back they are on the "buck-lands, uncovered by any alluvium. The local elevation of Greenville would be as to the "Dogwood Ridge" shown on the map of the Mississippi alluvial region nphreys and Abbot's report, as the only land above overflow in the Yazoo bot-

ly, the deepest boring of the whole series, No. 2 of Lake Providence, is unique despite of its great depth (248 feet), it has failed to reach the tertiary beds. Mr. was misled by the close resemblance of the clays at 131.5 feet and below, and the overlying lignite, into the belief that the rest of the boring was in tertiary ls, which conclusion was made more plausible by the occurrence of calcareous and materials resembling greatly the tertiary marls. The microscopic exami- however, leaves no doubt of the fresh water and "Port Hudson" character of the oring from at most 42.9 feet down. In this latitude, moreover, the outcrops of materials in the Yazoo bottom render the identification, even to the naked eye, er complete. How much deeper the trough was excavated into the tertiary at nt is open to conjecture; but the occurrence of the tertiary marl at 110 feet in No. 3 (at Hay's Landing), 6 miles southeast from Lake Providence, shows that trough was not continued in that direction, but more probably in a southwest-rse. In this connection it should not be forgotten that, as I have shown,* the ift current bore, not in the direction of the present mouths of the Mississippi, ard Vermilion Bay. This, therefore, is the direction in which we would expect the deepest excavations in the tertiary materials.

gards the comparative age of the marine tertiary beds at Lake Providence (or lays' Landing) and Choctaw Bar or Helena, the larger as well as the microscopic end to show that while the beds reached at the first-named locality have a some-fferent *facies* from those above, yet the horizon of the next higher group, the on," had not been reached. Now it is known that southeast of Hays' Landing 'azoo River, near Haines's Bluff, the Jackson strata begin to disappear beneath the evel, being there overlaid by a lignitic bed of variable thickness, which in its the Vicksburg bluff, is capped by the "Vicksburg" series. The dip of the ter-ing here very little west of south, it follows that at Hays's Landing the strata t 110.7 feet must belong to a group considerably below the Jackson beds; which ect what the fossils found also indicate. In other words, the bed belongs to the portion of the Claiborne group, and, according to the rate of dip observed at Vicks-e Jackson beds would not be reached in a boring of that depth until about the of Warrenton, south of Vicksburg.

general conclusions reached as regards the geological history and structure of the ttom within the limits of the borings in question are therefore these: A trough lepth exceeds at one point 248 feet below high-water mark has been excavated tertiary beds originally filling it probably to a height considerably above that This trough has subsequently been filled up to above present high-water mark posits dating, in their present position, from the period of gradual depression fol- the deposition of the orange sand, and during which the orange-sand materials oded and redeposited in the trough, or similar materials were brought *de novo*

geological details regarding this clay, refer to Dr. E. A. Smith's paper on the Geology of the pi Bottom, Proceedings A. A. A. S., 1871, p. 252.

from northern regions. The gravel and coarser sand were of course left in the [illegible] northerly portion of the trough, while in the southerly one the comparatively [illegible] water produced deposits of sandy loams, fine silt, and "buck-shot" clay. As the [illegible] sion increased and the slack-water advanced up the valley, finer materials [illegible] overlying the gravels, were deposited, and finally the loess and yellow loam [illegible] ing the uplands. Upon re-elevation the loam and loess in the middle [illegible] trough were washed away; but when the resistant buck-shot clays were [illegible] concentrated upon the lines of least resistance, and the river [illegible] great alluvial ridge in the axis of the valley [illegible] channel by the formation and cutting off of bends, its [illegible] the same. Where the river has [illegible] alluvium overlying such as remained; but [illegible] must, of course, be of corresponding thickness [illegible] more alluvium of such thickness has been [illegible] viz. 68.2 feet: the maximum [illegible] Lake Providence No. 3 boring 56.8 [illegible] 50 feet. This is in accord with the similarly shallow depths at which the [illegible] found to terminate in the lower delta.

It would be extremely desirable to verify the conclusion by the [illegible] of samples carefully taken, both of various kinds of [illegible] various materials of the noted out-crops of the Fort Hudson group. This [illegible] especially interesting in connection with borings made at points further south in [illegible] great valley itself.

PREFATORY LETTER BY DR. F. V. HOPKINS.

SAN FRANCISCO, CAL., May 1, 18[illegible]

Prof. E. W. HILGARD, *Ph. D.:*

DEAR SIR: The microscopic examination of the specimens submitted to me by [illegible] has now been carried as far as the objects had in view by the Mississippi River [illegible] mission will warrant. In fact, it has been carried much farther, for under the impre[illegible] that what was desired was a full account of their fossil contents, such as I had the p[illegible] of preparing for you in the case of the Lake Borgne borings in 1874. I figured [illegible] fully every organism observed. The tertiary marls proved to be very rich in foram[illegible] era, almost all of undescribed species, and one or two new genera [illegible] in order to describe them fully. This work, after having occupied my time for [illegible] unfortunately proves to be of little avail, the Commission having decided [illegible] to publish no plates with the report.

[illegible] I have done what I could to compare my [illegible] those [illegible] described, and have prepared lists of names, indicating the [illegible] of others that most strongly resemble the fossils observed. These [illegible] the following tables, and will [illegible] in the determination of the geological [illegible] of the strata through which the borings have passed. It is to be hoped that [illegible] the attention of naturalists to a rich and as yet unworked field for [illegible] research.

The specimens were prepared for examination by shaking, or in the case of [illegible] boiling, with about 4 inches of water in a 6-inch test-tube until the grains were separated. After settling, first for 25 seconds, the water containing the finer portion [illegible] decanted into another tube, and a fresh supply poured in. This process was [illegible] four times, the settling being 5 seconds shorter each time. The remaining portion [illegible] the separate deposits in the tubes were then examined carefully under a micros[illegible] with powers varying from 70 to 1,100 diameters. The results are set forth in the fol[illegible] ing tables.

Yours, very truly,

F. V. HOPKI[illegible]

* Smithsonian Contributions to Science, No. 218; also, Proceedings A. A. A. S., 1871, p. 230.[illegible]

† The height at which we find the tertiary beds at this time on the bordering bluffs is [illegible] not a fair measure of the amount of erosion, since the axis of the Mississippi embayment w[illegible] doubtedly a trough lower than its border.

Record of examination of specimens of borings.

[...copic character by Dr. F. V. Hopkins; larger organisms and final determination of the strata by Prof. E. W. Hilgard.]

BORING NO. 2, MEMPHIS, TENN. (ON BLUFF).

...iption of specimens.	Depth.	Quartz.	Tourmaline	Vegetable matter.	Mica.	Large fossils.	Small fossils.
LOESS.	*Feet.*						
...r silt, non-calca...s.	1 to 47	Small rounded and clear.	None..	A little.	None..	None..	None.
...RANGE SAND.							
...e yellow, coarse ...l.	47 to 55.9	Variegated with pebbles.	None..	None..	None..	(*)	None.
...lay, with yellow ...ks.	55.9 to 60.6	Small, clear, and rounded.	....do....	....do....	....do....	None..	Do.
...wish sand..........	60.6 to 63	Clear, mixed with chert and jasper.	....do....	....do....	....do....	....do....	Do.
...se sand with ...el.	63 to 93.9	Sharp and rounded, clear, white, yellow, red, and black.	....do....	....do....	A little.	(†)	Do.
...e-colored sand...	93.9 to 99.8	Variegated..........	....do....	....do....	....do....	None.	Do.
...e-colored sand, ...relly.	99.8 to 117	......do..............	....do....	....do....	....do....	(†)	Do.
...e-colored sand, ...er part cemented by iron into a ...lomerate.	117.5 to 132.2	......do..............	....do....	....do....	....do....	(†)	Do.
...sh clay..............	132.2 to 132.5	Fine and clear......	....do....	....do....	....do....	None..	Do.
...e yellowish sand.	132.5 to 133.4	Variegated..........	....do....	....do....	....do....	....do....	Do.
...sh clay..............	133.4 to 134.1	Fine and clear.......	....do....	....do....	....do....	....do....	Do.
...e yellowish sand.	134.1 to 139.3	Variegated...........	....do....	....do....	(‡)	....do....	Do.
...ERN LIGNITIC ...TERTIARY.							
...grange Group.							
...r clay, yellow-... passing into ...sh gray.	139.3 to 150	Clear, small, and rounded.	None..	(§)	None..	None..	None.
...sand...............	150 to 154.5	Rounded and sharp, clear, some white and yellow.	....do....	....do....	....do....	....do....	Do.
...twoods Group.							
...ise clay............	154 to 167	Very small, clear, and round.	None..	None..	None..	None..	None.
...sh sand............	167 to 168.5	Clear and round.....	....do....	....do....	....do....	....do....	Do.
...ise clay............	168.5 to 275.1	Fine and clear.......	....do....	(‖)	....do....	....do....	Do.

*...s of palæozoic in pebbles. † Casts in pebbles. ‡ A good deal. § Lignite grains and larger pieces ‖ Lignite grains.

NOTES ON MEMPHIS SECTION, BORINGS NOS. 1 AND 2.

(E. W. HILGARD.)

...e loess specimens within the first 47.2 feet agree entirely with the usual character ...is deposit in the northerly region. It is much less calcareous than farther south, ...nails, as well as concretions of calcic carbonate, occur only in streaks, sporadically. ...upper 10 feet are properly a subsoil layer belonging to the "yellow-loam" divis... which in the interior is directly superimposed upon the orange sand or stratified ...

...e latter presents here a most characteristic section, embracing a series of all its ...acteristic materials, even to the ferruginous conglomerate of coarse sandstone, which ..., as elsewhere, marks the approach to an impervious or clayey layer. The lowest ...on of the loess also shows for a few feet a change toward a sandy hardpan, which ...lly forms a transition to the orange sand proper; and at the base of the latter the ...ase of sharp sand-grains, as against the rounded and rust-incrusted ones, heralds ...pproach of the tertiary sands that commonly form the upper portion of the "La-

grange groupe in Tennessee. The great clay bed with occasional streaks of gray sand is the exact counterpart of sections obtained in bored wells in the "Flatwood belt" in Mississippi, including the variation in sandiness that is so apparent between 230 and 245 feet of the section. As these clays immediately overlie the highest cretaceous of the southwestern States, it is probable that between 100 and 200 feet lower down the cretaceous limestone would have been reached after passing through a zone of estuarian deposits with silicified marine fossils. The dark-colored concerctions found at 184.7 and 204 feet are mostly of bird-shot size, and consist of sand-grains cemented by brown iron ore, evidently a pseudomorph after iron pyrites. They are therefore not calcareous, as stated in the record of borings; nor does the material inclosing them show any signs of effervescence. Had it been otherwise, the fact would have been of especial interest, as indicating the approach of oldest marine tertiary strata found at some points in Mississippi and Alabama.

Boring No. 3 manifestly agrees in all prominent points with the sections obtained in the bottom borings at Helena, Choctaw Bar, and Lake Providence; viz: the tertiary strata are overlaid first by a heavy deposit of gravel and gravelly sand, this by finer sand, and this finally by the obviously alluvial layers.

[Specimens from below the depth of 21 feet. No microscopic organisms detected.]

Description of specimens.	Depth.	Quartz.	Mica.	Lignite.
Port Hudson.	Feet.			
Fine sand	21 to 45.0	Grains clear, rounded, and sharp, some red; largest .085 inch in diameter.	But little; some red and green, mostly colorless; no tourmaline.	None.
Fine sand	45 to 87.4	As above, from .017 inches down.	Plentiful in broad plates	Abundant. Too ripe for an alluvial deposit.
Coarser sand with gravel	87.4 to 116.4	Rounded, mostly colorless, but varied with milky quartz, carnelian, yellowish chert, &c.	None	Do.
Clean sand with gravel	116.4 to 142.7	Perfectly rounded, mostly clear; some spotted with carnelian, chert, jasper, quartz, &c., and fragments of composite rocks, gray and brown.	do	Not very abundant.
Coarse sand	142.7 to 156.8	do	do	Do.
Finer sand	156.8 to 161.5	do	do	Do.
Coarse sand	161.5 to 162.3	do	do	Do.
Northern lignite (tertiary):				
Smooth blue clay	162.3 to 189.5	Very fine, clear, and rounded	do	Abundant and ripe.
Lignite in mass	189.5 to 189.7	None	do	Well ripened.
Smooth blue clay	189.7 to 206.4	Very fine, clear, and round	do	In grains, ripe as last.

Claiborne group of tertiary strata: Clayey green sand marl.....	*Feet.* 229.5 to 231.3	Clear and round; $\frac{1}{100}$ of an inch in diameter and less.	A little in crystals.	Same species as at 171 3.	*Planulina* n. *ampla* Ehr. two species. Do. n. *octenaria* Ehr. Do. n. *cornu* Ehr. *Cristellaria*, sp. undet. 2. Do. n. *arcuata* Williamson. *Lenticulina*, n. discus, Ehr. *Discorbina*, ten species undet. *Rotalia*, two species undet. *Rotalina*, n. Ehrenbergii Bailey. *Globigerina*, sp. undet. Do. n. *helicina*, Carp. *Sphaeroidina*, sp. *Polystomella* n. *craticulata*, Carp. *Glandulina* n. *laevigata*, D. orb. *Strophoconus*, sp. undet. *Polymorphina*, sp. undet. No. 1. *Vaginulina* n. *tenuis*, Ehr. *Textilaria*, 3 species undet.
Do......................................	231 to 231.3	........do..	Crystals..................	......do....................	*Rhizopoda*, *Plagiophrys*, sp. undet. *Haliomma*, n. *ovatum*, Ehr. *Foraminifera*, as follows: *Miliola*, n. *ovum*, Ehr. *Gromia*, sp. undet. *Lagena* (*entosolenia*), n. *globosa*, W. Do. n. *squamosa*, W. Do. n. *marginata*, W. *Rotalina*, n. Ehrenbergii Bailey. *Cristellaria*, n. *arcuata*, W. sp. 2. Do. sp. No. 3, undet. Do. sp. No. 4, undet. *Globigerina*, sp. No. 3, undet. *Discorbina*, sp. No. 11, undet. *Bulimina*, sp. undet.
Clay-colored calcareous rock.	231.3	........do..	None..................	Fragments...........	None.
Dark sandy clay, with pebbles.	234 to 236.8	........do..	......do..................	None....................	None.
Clay-colored sand*............	236.8	Clear, sharp, and rounded, some grains spotted with carnelian.	Rare..................	Fragments very abundant.	*Lagena* (*entosolenia*), n. *marginata*, W. sp. No. 2. *Cornuspira*, sp. undet. *Trochammina gordialis*, Carp. *Spiroloculina*, sp. undet.

* By some mistake Mr. Wilson reports the last specimen as "limestone."

NOTES ON THE HELENA SECTION.

(E. W. HILGARD.)

BORING NO. 2 (ON BLUFF).

The first 139.7 feet of this section is highly typical loess, with land snails (*Helix* a *labris*) and loess puppets or calcareous concretions of the silty mass. It differs quite viously from the yellowish and much more clayey material of the Memphis bluff and marginal region of the loess in Tennessee and north Mississippi generally, which m properly be distinguished as "marginal loess."

The materials found from 139.7 to 158 feet, though non-effervescent, seem most clo related to the loess, and, with the underlying siliceous clays, seem to correspond to transition strata between the loess and orange sand observed at Vicksburg and Gr Gulf, Miss.

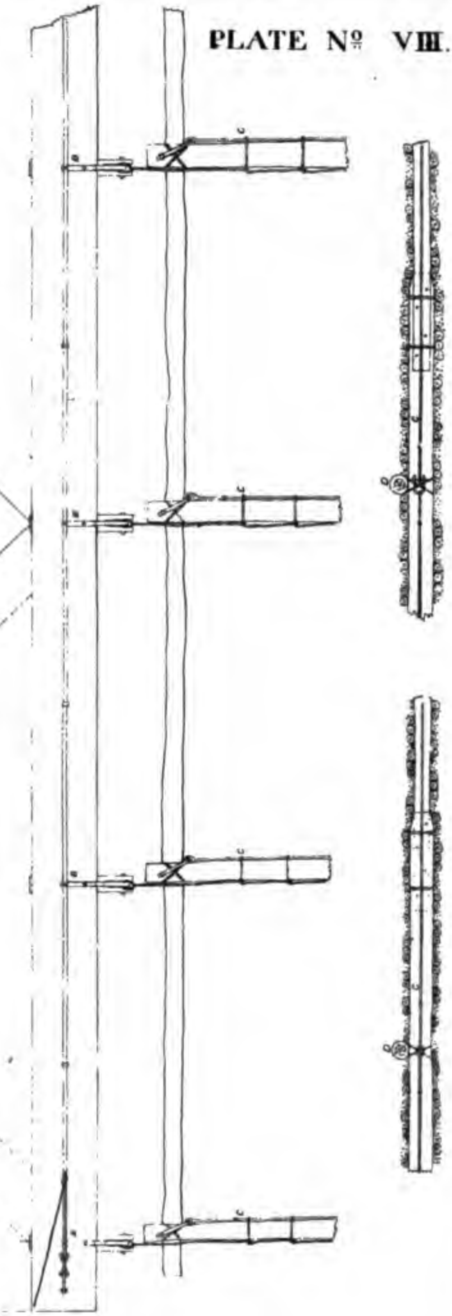
The pebble bed at 167.8 to 171.3 doubtless represents the orange sand pebble bed, wh has been found of such very variable thickness by Mr. Wilson in this very locality, shows the same variability almost everywhere else.

The fossiliferous clay and marl bed, 171.3 to 231.3, with its intercalated layer of bl impure limestone, is very distinctly characterized as tertiary, of the (marine) Claib Group by the well-preserved specimens of the following shells: *Monoceros vetustus* L *Actæon lineatus* Lea, *Nucula magna* Lea, *Dentalium turritum* Lea, or *microstriatum* He *Natica minima* Lea, *N. magno-umbilicata* Lea, *Pleurotoma Lonsdalii* Lea; there is be an undescribed *Pleurotoma*, *Flabellum*, and *Retepora*. The abundance of microscopic ganisms shown by Dr. Hopkins's record is very remarkable.

BORING NO. 1 (IN BOTTOM).

This boring begins at a level about 138 feet lower than No. 2, and reaches to a de greater by 116 feet. After penetrating 27 feet of unquestionable alluvium, it penetr first 56.4 feet of very fine and uniform sand, which then becomes coarser and slig gravelly through the succeeding 29 feet, making 85.4 feet of sand. The materials t become gravelly and pebbly, and so continue with variations to 162.3 feet, making i 131.3 feet of sandy and gravelly materials, the physical composition of which shows t to belong to one and the same epoch. Then follow strata of solid clays, void of ma fossils, but agreeing in every character with the "northern lignitic" clays penetrated the Memphis boring at the lower depths. Helena boring No. 1 has therefore passed yond the limits of the marine Claiborne strata found in boring No. 2, reaching the old underlying tertiary at the lowest level at which it has been found in the borings un consideration, viz, 162.3 feet below the high-water reference level. The ready disi gration of the calcareous marls has allowed the ancient floods, charged with gravel, wear them away down to their tough floor clays; the latter, contrary to the statem the boring record, show no signs of calcareous matter.

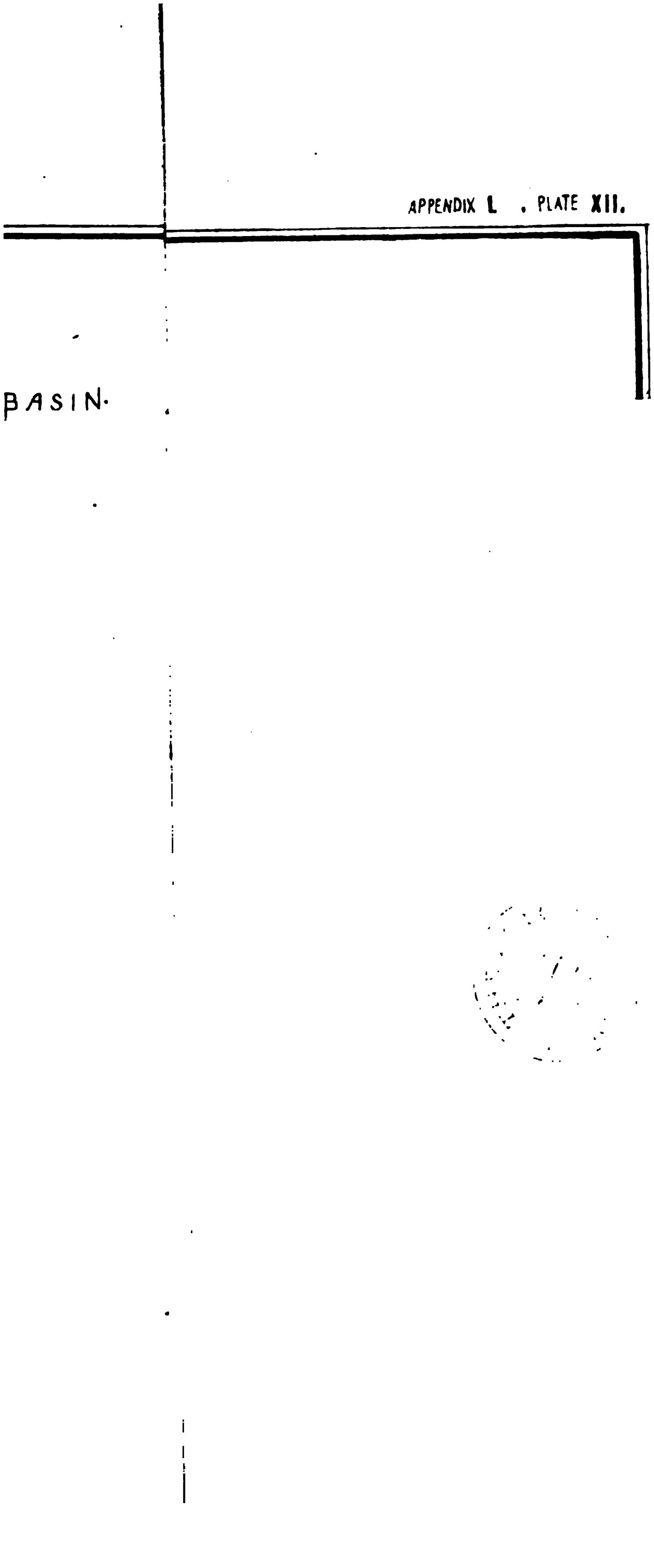
PLATE No. VIII.



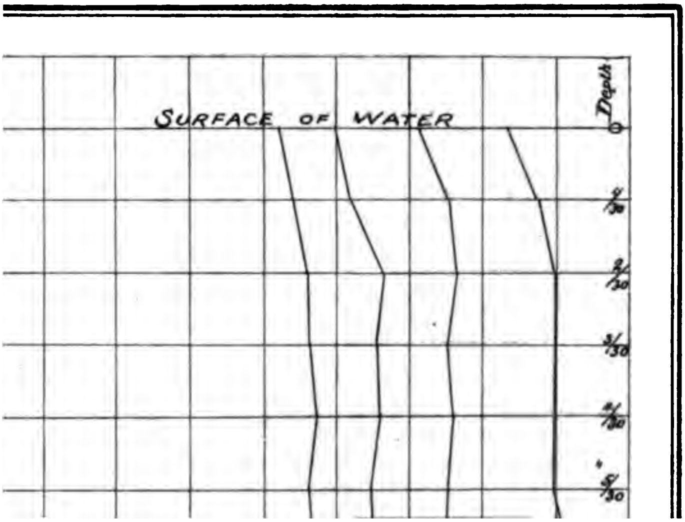
LAKE PROVIDENCE (LOUISIANA) BORING, No. 8.

Description of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
	Feet.				
Alluvium: Non-calcareous clayey silt with abundant vegetable matter, not lignitized. The color is yellowish above, yellow streaked below, and more reddish at the bottom. The proportion of clay varies also every few feet.	0 to 56	Rounded, clear, averaging .002 inch in size; some red grains.	A little	None	None.
Port Hudson: Coarse sand with gravel and grains of lignite. A clay streak occurs at 82.5 to 82.6.	56 to 100	Pebbles chert quartzite, &c.; larger sand grains averaging .05 inch, well rounded; smaller, sharp; clear, green, red, and red-spotted.	Very little	Very little	Do.
Upper Claiborne (tertiary): Whitish green sand marl. On washing and settling the green sand falls to the bottom, the red sand occupies the middle, and the calcareous débris lies on top.	127 to 132	Almost all red-spotted, rounded and sharp.	None	None	*Foraminifera* very abundant. *Porospira*, n. *princeps*, Ehr. *Miliolina seminulum*, n. var. *oblonga*, Williamson. *Planulina*, n. *ocellaris*, Ehr. *Miliolina*, n. *seminulum*, W. *Cristellaria*, sp. undet., No. 8. *Guttulina*, n. *turrita* Rects. *Textilaria*, n. *cuneiformis* Dorb. *Textilaria*, n. *variabilis*, W. *Pyrulina*, n. *ovulum*, Ehr. *Rotalina*, n. *Ehrenbergii*, Bailey. *Globigerina*, n. *helicina*, Carp. *Polymorphina*, sp. undet. *Uvigerina*. sp. undet. *Textilaria variabilis*, variety near *spathula*, W. *Discorbina*, sps. undet., Nos. 15, 16, and 17. *Truncatulina*, sps. undet., Nos. 1, 2, and 3. *Truncatulina*, near *lobulata*, Walker. *Tinoporus*, sp. undet.

APPENDIX L . PLATE XII.



APPENDIX M , PLATE II.



BORING No. 2, HELENA, ARK.

Description of specimens.	Depth.	Quartz.	Tourmaline.	Large fossils.	Small fossils.
	Feet.				
Loess:					
Brownish-yellow loam, non-calcareous.	0 to 0.5	Brown yellow and clear; grains from .03 of an inch down, smaller, grains sharp, larger rounded.	None	None	None.
Yellow silt, calcareous, and full of snail shells and concretions of lime called "loess puppets."	0.5 to 139.7	Clear rounded and sharp, from .002 of an inch down.	Green crystals of tourmaline.	*Helix albolabris* (Say)	Do.
Transition stratum:					
Yellowish clay	139.7 to 167.8	Clear rounded .002 of an inch and less in diamter.	None	None	Do.
Orange sand (drift):					
Chert pebbles	167.8 to 171.3	Yellowish chert, well rounded, often several inches in diameter; full of casts.	do	Casts of palæozoic fossils	Do.
Claiborne group of Tertiary strata (Marine):					
Stiff blue clay, with green sand and lignitized sea-weed.	171.3 to 199	Clear and round; some carnelian.	A little crystallized	*Corbula*, *Turbinolia*, *Natica magno-umbilicata*, *Voluta petrosa*.	Do.
Stiff blue clay, calcareous; a clayey green-sand marl.	199 to 211.2	do	do	*Corbula*, *Turbinolia*, *Natica magno-umbilicata*, *Voluta petrosa*, fragments.	Do.
Ferruginous concretion of stony hardness.	211.2 to 211.4	do	None	Fragments	Do.
Clayey green-sand marl	211.4 to 212.8	Clear and round, $\frac{1}{100}$ of an inch in diameter, and less.	A little in crystals	Same species as at 171.3	Do.
Do.	212.8 to 222	do	do	do	Spot of *Dentalium*.
Do.	222 to 229.5	do	do	do	Spot of *Dentalium*, with spot of *Ostrea*.
Do.	229.5 to 231.3	do	do	do	Abounding in foraminifera, viz: *Planulina*, sp.; *Planulina*, near *P. leptostigma* Ehr.

Claiborne group of tertiary strata:					
Clayey green sand marl	*Feet.* 229.5 to 231.3	Clear and round; $\frac{1}{60}$ of an inch in diameter and less.	A little in crystals.	Same species as at 171 3.	*Planulina* n. *ampla* Ehr. two species. Do. n. *octenaria* Ehr. Do. n. *cornu* Ehr. *Cristellaria*, sp. undet. 2. Do. n. *arcuata* Williamson. *Lenticulina*, n. discus, Ehr. *Discorbina*, ten species undet. *Rotalia*, two species undet. *Rotalina*, n. Ehrenbergii Bailey. *Globigerina*, sp. undet. Do. n. *helicina*, Carp. *Sphaeroidina*, sp. *Polystomella* n. *craticulata*, Carp. *Glandulina* n. *laevigata*, D. orb. *Strophoconus*, sp. undet. *Polymorphina*, sp. undet. No. 1. *Vaginulina* n. *tenuis*, Ehr. *Textilaria*, 3 species undet.
Do.	231 to 231.3	do.	Crystals	do.	*Rhizopoda*, *Plagiophrys*, sp. undet. *Haliomma*, n. *ovatum*, Ehr. *Foraminifera*, as follows: *Miliola*, n. *ovum*, Ehr. *Gromia*, sp. undet. *Lagena* (*entosolenia*), n. *globosa*, W. Do. n. *squamosa*, W. Do. n. *marginata*, W. *Rotalina*, n. Ehrenbergii Bailey. *Cristellaria*, n. *arcuata*, W. sp. 2. Do. sp. No. 3, undet. Do. sp. No. 4, undet. *Globigerina*, sp. No. 3, undet. *Discorbina*, sp. No. 11, undet. *Bulimina*, sp. undet.
Clay-colored calcareous rock.	231.3	do.	None	Fragments	None.
Dark sandy clay, with pebbles.	234 to 236.8	do.	do.	None	None.
Clay-colored sand*	236.8	Clear, sharp, and rounded, some grains spotted with carnelian.	Rare	Fragments very abundant.	*Lagena* (*entosolenia*), n. *marginata*, W. sp. No. 2. *Cornuspira*, sp. undet. *Trochammina gordialis*, Carp. *Spiroloculina*, sp. undet.

* By some mistake Mr. Wilson reports the last specimen as "limestone."

INDEX.

Subject.	Page. Part I.		Part II.
Red River, La., improvement of	221		132
survey of	221	227	
Red River of the North, improvement of	248		
Red River of the North, construction of lock and dam at Goose Rapids	248		
Red River, Tenn., improvement of	259		
Redwood Slough, Cal., examination and survey of	334		
Reedy Island, Delaware River, ice-harbor at	129	817	
Reservoirs at sources of the Mississippi and its tributaries, construction of	249		
Reservoirs at sources of the Mississippi and its tributaries, surveys for	250		
River and harbor improvements	66		
Roanoke River, N. C., examination and survey of	163		102
Roanoke River, N. C., improvement of	161		100
Rochester, Pa., examination and survey of Ohio River at for ice-breaker	263		
Rock Island Harbor, Mississippi River, improvement at	241		
Rock Island Rapids, Mississippi River, improvement at	241		
Rockland Harbor, Me., improvement of	69	464	
Rockport, Mass., examination for harbor of refuge at Sandy Bay	79	565	
Rocky River Harbor, Ohio, improvement of	315		
Roebuck Lake, Miss., examination of	227		135
Romerly Marsh, Ga., improvement of water-route through	186		111
Rondout Harbor, N. Y., improvement of	102	700	
Roundaway Bayou, La., examination of	227		134
Rouse's Point, N. Y., examination and survey for breakwater at	330		
Royal River, Me., improvement of	70	466	

S.

Sabine Pass and Calcasieu River, examination for water-route to connect	216		128
Sabine Pass, Tex., improvement of	207		124
Sabine River, Tex., improvement of	208		125
Sackett's Harbor, N. Y., improvement of	326		
Saco River, Me., resurvey of	73	482	
Sacramento River, Cal., improvement of	331		
Saginaw River, Mich., improvement of	304		
Saint Anthony, preservation of Falls of	244		
Saint Augustine Creek, Ga., improvement of	186		111
Saint Augustine, Fla., defenses of	45		
Saint Clair Flats Ship-canal, Mich.	306		
Saint Croix River, Wis. and Minn., improvement of	247		
Saint Croix River, bridging	270		
Saint Francis and White rivers, Ark., improvement of	228		139
Saint Jerome's Creek, Md., improvement of harbor at	156		98
Saint John's River and Fernandina, Fla., deepening inside passage between	190		112
Saint John's River, Fla., examination and survey between Lake George and Lake Monroe	194		113
Saint John's River, Fla., improvement of bar at mouth of	190		112
Saint John's River, Fla., Upper, improvement of	193		113
Saint Jones River, Del., improvement of	133	835	
Saint Joseph Harbor, Mich., improvement of	300		
Saint Mark's River, Fla., examination of	206		122
Saint Mary's Falls Canal and Saint Mary's River, Mich., improvement of	302		

T.

Y.